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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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T. RYAN,
Director-General. U 913

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By Order of the Board,
OSWALD I. MILNE,
Secretary.
1st August, 1922. U 934

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Town Hall,
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July 6th, 1922.
U 780

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CALCUTTA IMPROVEMENT TRUST.

A Temporary Assistant En-

GINEER is REQUIRED to supervise the construction of a 3-hinged REINFORCED CONCRETE ARCH BRIDGE of 128 ft. span in the north of Calcutta.

Candidates must have had several years' practical experience in the construction of arch bridges or similar important works in reinforced concrete. Salary Rs.1000 (one thousand) per mensem, with a motor car allowance of Rs.100 (one hundred) per mensem and a free passage to and from Calcutta. Appointment for two years, subject to six months' notice on either side. Applications will be received up to the 31st August, 1922, in England by C. H. Bompas, Esq., C.S.I., I.C.S., Mayfield, Seaton, Devon, and in India by the Chief Engineer, Calcutta Improvement Trust, 5, Clive Street, Calcutta.

T. EMERSON,
Chairman.
Calcutta,
4th July, 1922. U 907

Thoroughly Practical In-

SPECTOR WANTED. Engagement 10 to 12 months. Must be well up in modern shipbuilding methods and with a good knowledge of mechanical engineering; some knowledge of electrical work an advantage. First-class men only, with considerable practical experience in this class of work need apply.—Address, stating age, experience, salary expected, with copies of testimonials, U 944, Offices of Engineering.

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years' experience railway survey, location, construction, maintenance; buildings; canal and harbour survey; ferro-concrete construction on large scale; employed on leading railway; owing to changed conditions in India, SEEKS HOME APPOINTMENT elsewhere. Excellent references. Energetic, good organiser. Suit large firm of contractors.—Address, U 904, Offices of Engineering.]

(To face page 132.)

TURBINE-DRIVEN LOCOMOTIVE: SPRING DRIVE.

CONSTRUCTED BY THE AKTIEBOLAGET LJUNGSTRÖMS ANGTURBIN, ENGINEERS, STOCKHOLM.

(*For Description, see Page* 131.)

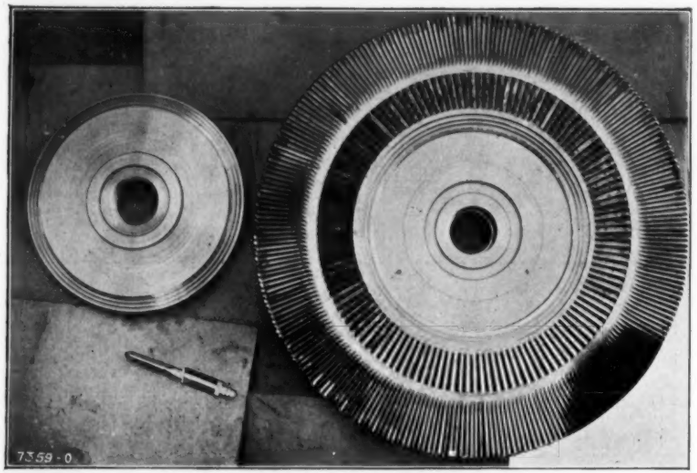


FIG. 36. TURBINE WHEEL WITH DOUBLE BLADING.

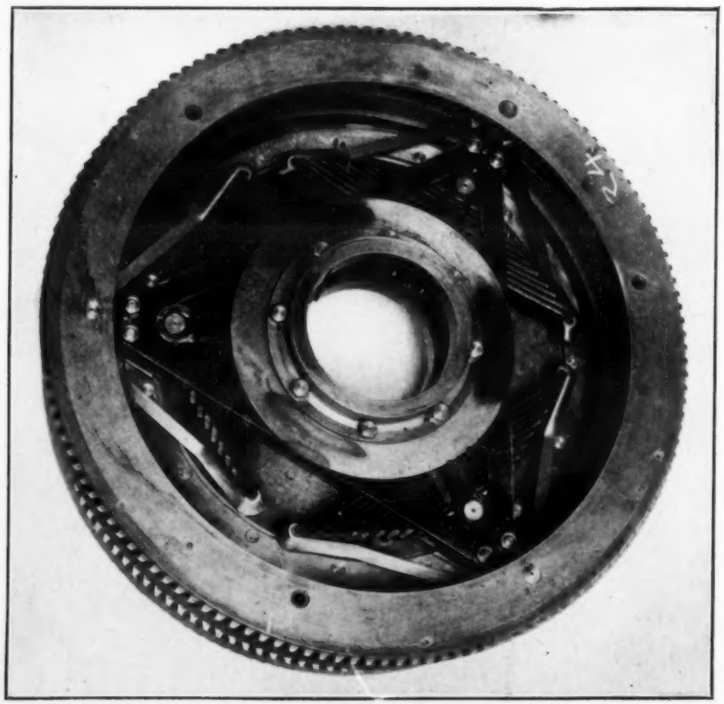


FIG. 39. SPRING DRIVE IN GEAR WHEEL.

Fig. 37.

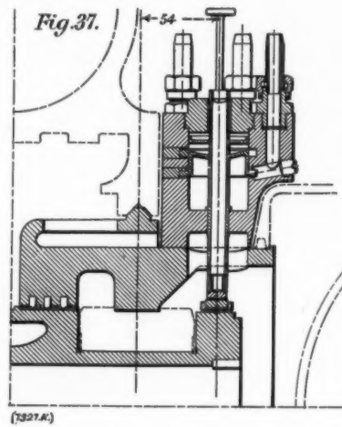


Fig. 38.

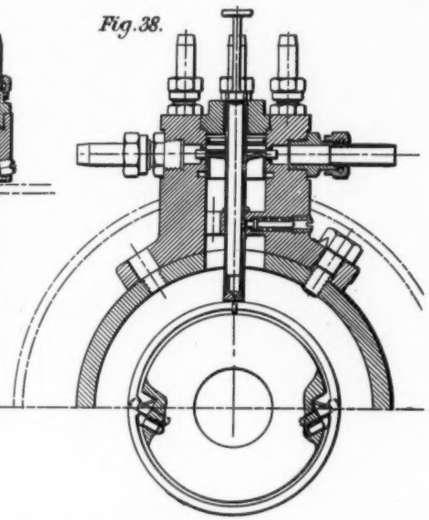


Fig. 40.

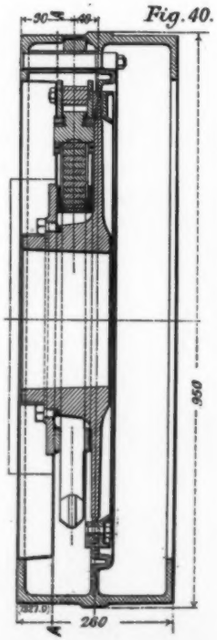
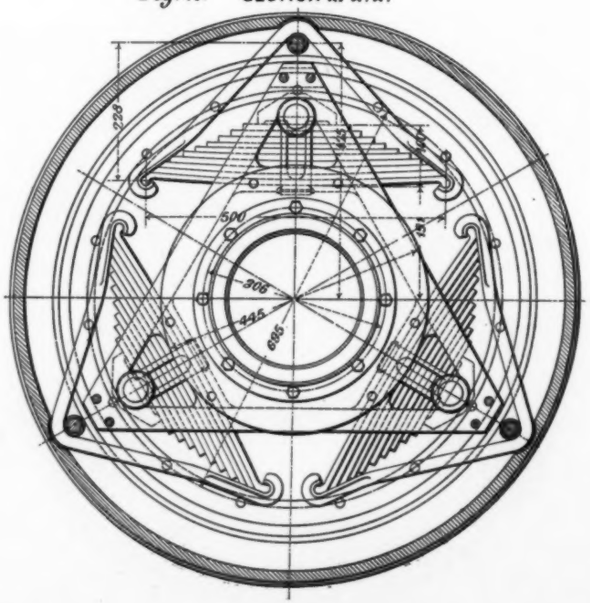
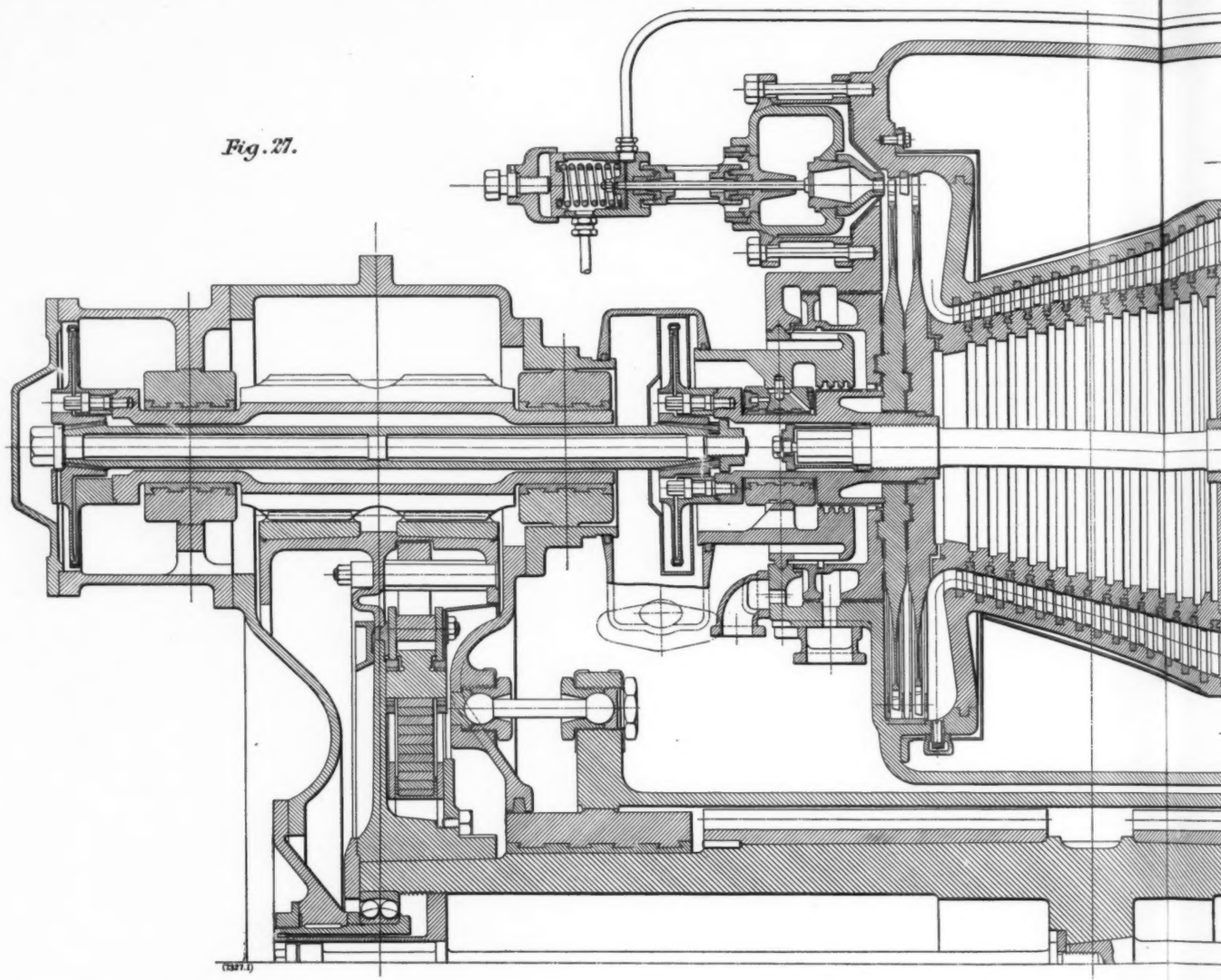


Fig. 41. SECTION AT A. A.



THE LJUNGSTRÖM TURBINE-DRIVEN LOCOMOTIV

Fig. 27.



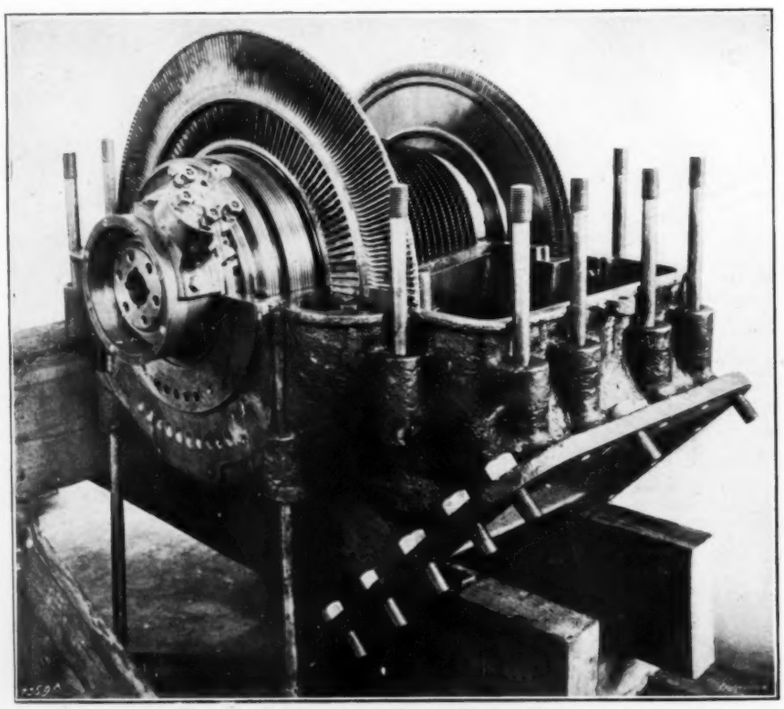


Fig. 28. Turbine with Casing Partly Removed.

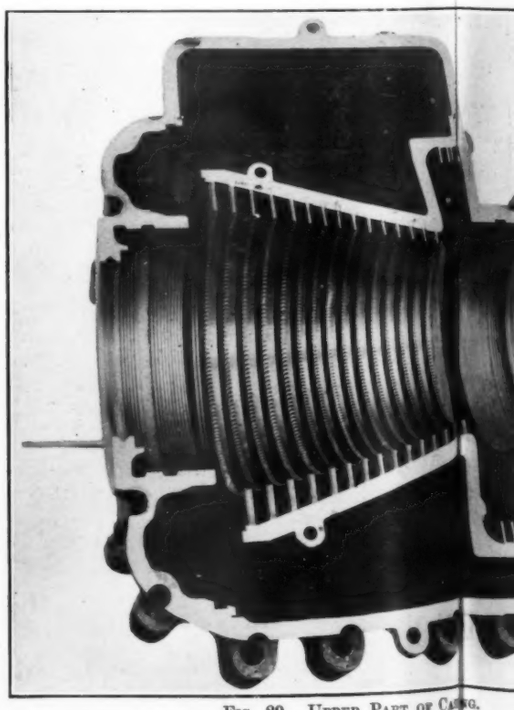
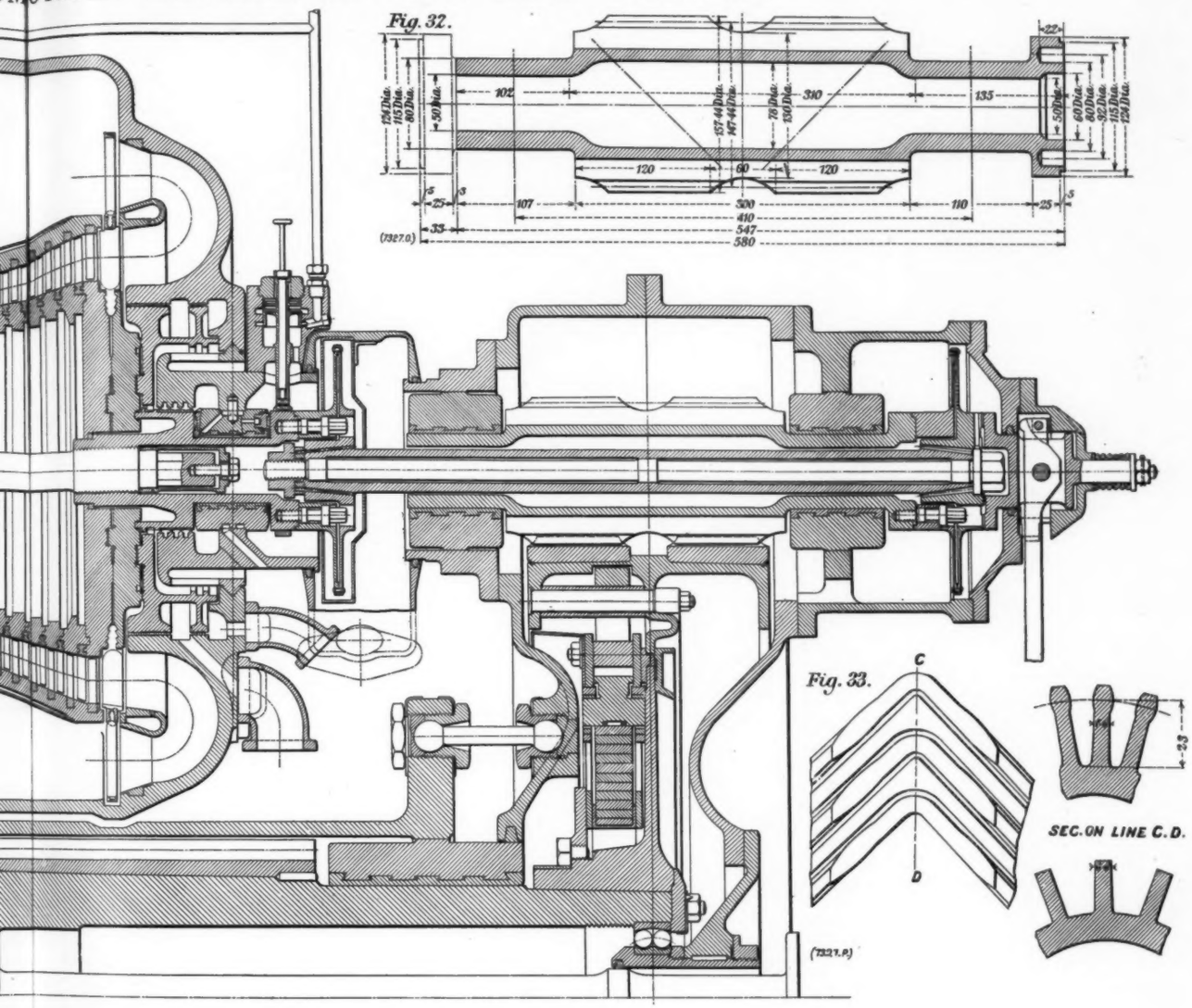
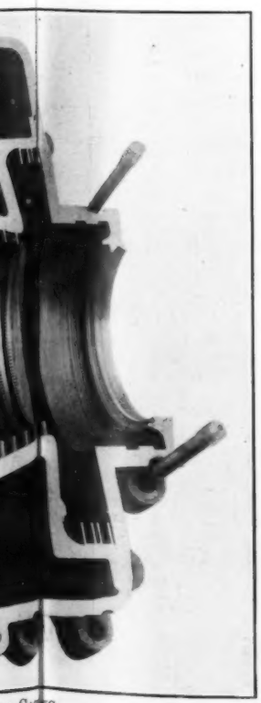


Fig. 29. Upper Part of Casing.

OMOTIVE: DETAILS OF THE MAIN TURBINE.





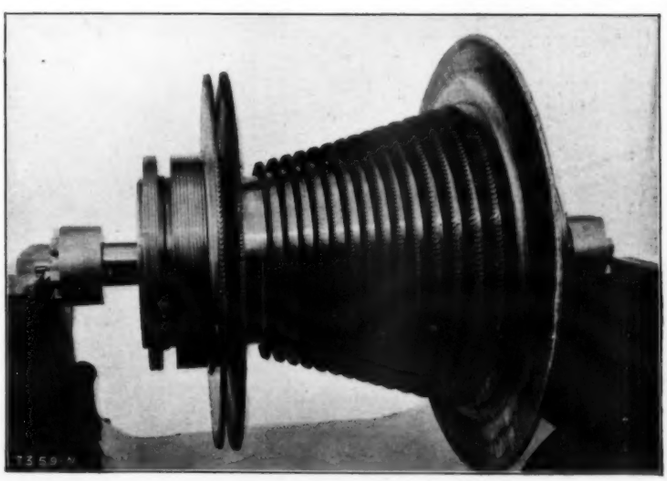


Fig. 30. Turbine Rotor.

Fig. 31. High Speed Pinion.

OF CARGO.

TURBINE-DRIVEN LOCOMOTIVE: DETAILS OF GEAR AND CASING.

CONSTRUCTED BY THE AKTIEBOLAGET LJUNGSTRÖMS ANGTURBIN, ENGINEERS, STOCKHOLM.

(*For Description, see Page* 131.)

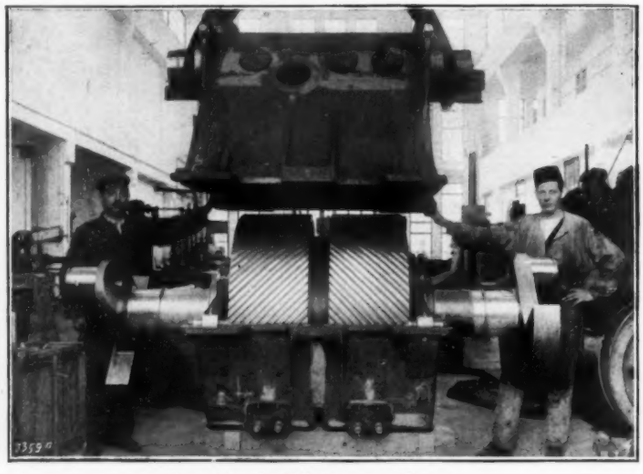


FIG. 44. JACK-SHAFT AND CASING.

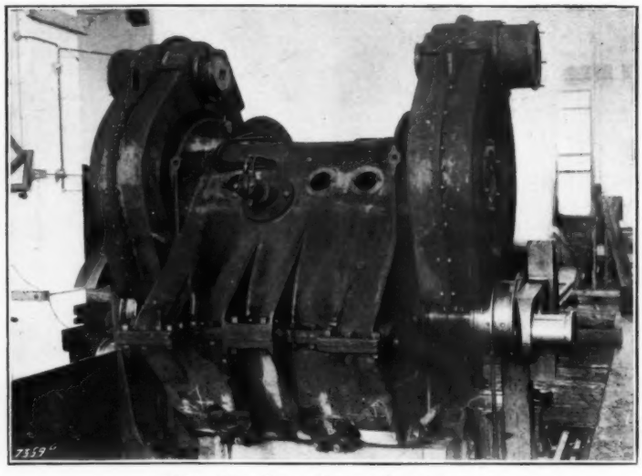
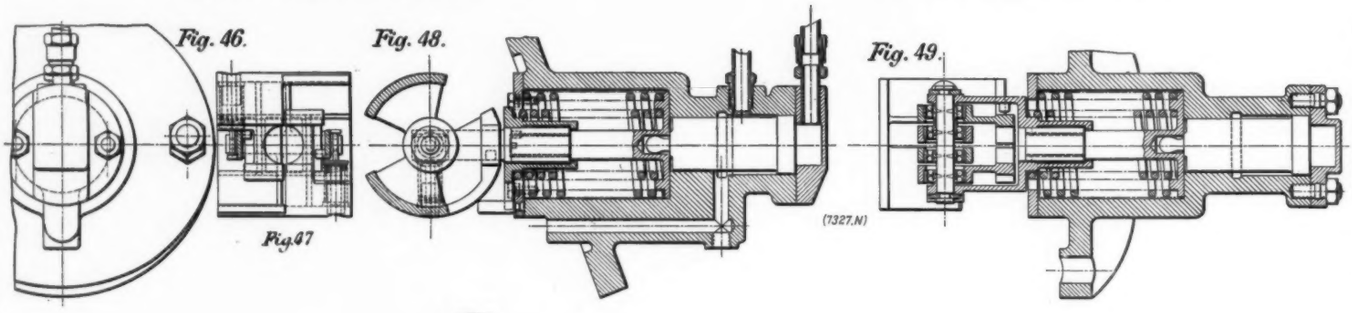
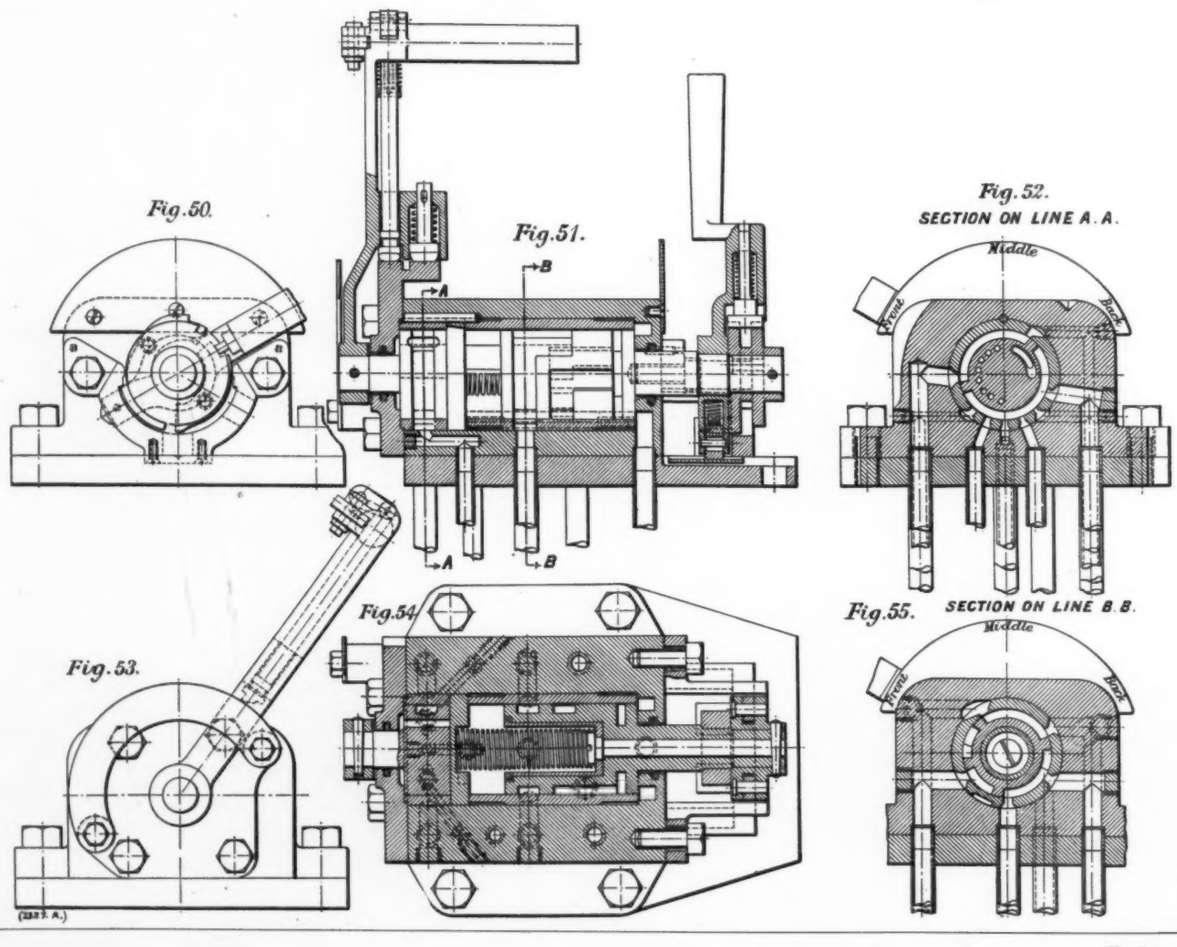


FIG. 45. GEAR CASING ASSEMBLED.





(*To face page* 133.)

THE LJUNGSTRÖM TURBINE LOCOMOTIVE.

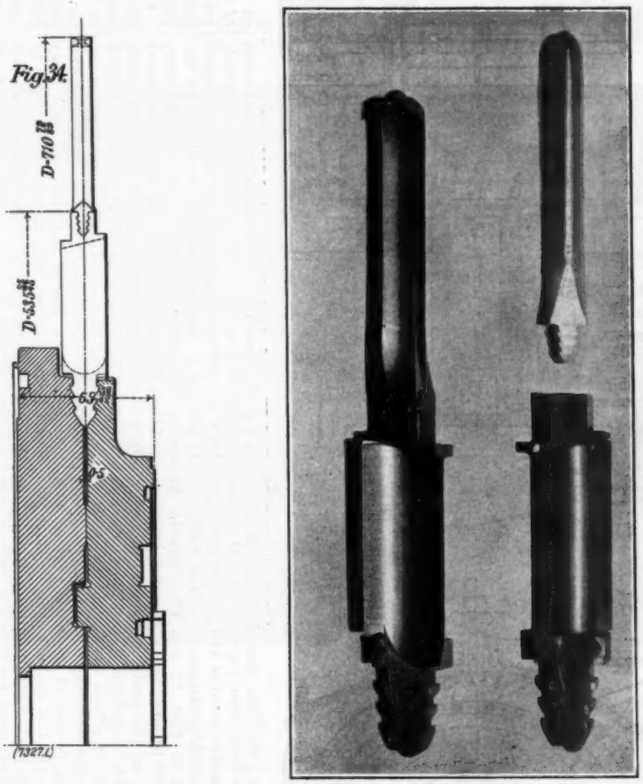
(*Continued from page* 70.)

THE MAIN TURBINE.

THE main turbine of the Ljungström locomotive is of the impulse-reaction type with the ordinary axial direction of steam flow, and it does not therefore embody the principles of radial flow and double rotation which are typical of Ljungström turbines for stationary and marine practice. It is situated at the back of the footplate and is carried on the front end of the condenser car. The position of the turbine is shown in Figs. 3 and 4, Plate VIII *ante*, and Fig. 10, page 66 *ante*. It lies transversely to the track, and drives the three driving axles of the condenser car by means of double reduction gearing and coupling rods. A longitudinal section through the main turbine and first reduction gearing is given in Fig. 27, Plate XIV, published with the present issue. Fig. 28 shows the appearance of the turbine with half the casing removed and the rotor exposed to view; Fig. 29 illustrates the top half of the casing, and Fig. 30 shows the rotor separately. The turbine develops 1,800 b.h.p. at 9,200 revolutions, which corresponds to the maximum locomotive speed of 110 km. (68·3 miles) per hour.

Steam from the boiler is led to the turbine by a steel pipe rendered sufficiently flexible by a U-shaped bend between the two cars which constitute the whole locomotive. The method of coupling these cars together, which will be referred to again later, prevents any large amount of relative motion between them, and no trouble has been experienced with the steam pipe or its joints. The pipe supplies steam to a cast steel steam chest containing five nozzles, each of which is independently controlled by a valve operated by oil pressure. The valves are normally held closed by springs, but each is opened as desired by the admission of oil pressure beneath a piston attached to the valve spindle, as will be understood from Fig. 27. The steam emerging from the nozzles acts first on what is in effect a velocity-compounded impulse wheel with two moving rows of blades, but in view of the very high speed of rotation it has been found advisable to build up the wheel of two separate discs mounted side by side and registered together. The blades are held in the wheel rims by means of bulb-headed roots inserted sideways in key-hole shaped slots, the practice being similar to that adopted in De Laval turbines.

After acting upon the impulse blading, the steam passes through the reaction blading, the moving rows of which project from what is virtually a tapered drum. It is not solid, however, but is built up of a number of rings registering together, and holding the blading between them. The blades in a row are not independent of each other, but have their roots welded together into a foundation ring of steel, so that the whole construction is of great mechanical strength. The foundation rings have rectangular grooves on each side which are engaged by corresponding projecting rings on the sides of the drum rings. The whole of the rotor, including the impulse discs, is locked together by means of large steel nuts on the shaft, these nuts also acting as journals for the shaft. The successive rings, forming the body of the rotor are so fitted together that when assembled each ring tends to compress its neighbour on the left by a certain definite amount. The object of this is to ensure as far as possible that the whole construction shall be equally tight and equally stressed under the conditions which obtain when running. The blading at the exhaust end of the turbine should be particularly noticed. It will be seen that the last blade row of the rotor is double, an inner ring of blades carrying an outer ring at their tips. The arrangement is shown more clearly in Figs. 34 and 35, annexed, while Fig. 36, Plate XIII, shows the assembled wheel. The inner blades are strong and substantial, in order to withstand the extra stress upon them, and they are held by serrated roots between the two discs in which the low-pressure end of the rotor terminates. Each of these blades carries at its tip a pair of smaller blades likewise made with serrated roots, which engage with the top of the inner blades. The steam passes first through the inner blades, and is then reversed by a passage in the turbine casing, and turned so as to flow axially backwards through the outer blades, being properly directed on to the latter by means of guides.



FIGS. 34 AND 35. DOUBLE BLADING.

The arrangement described affords a most ingenious and effective means of shortening the turbine, by enabling the necessarily large exhaust branch to be placed opposite the centre of the turbine rotor. The ordinary design of turbine in which the exhaust is taken off at the end of the casing would have been quite impossible in the present case, because its adoption would not nearly have permitted the turbine and gear pinions to have been got into the space available in the width of the locomotive. The higher speed and the larger mean diameter of the last row of running blades, which their position involves, is a special advantage on account of the great volume of the steam at this point. The only objection which can be raised against the plan of turning back the steam is that it jackets the reaction part of the turbine with exhaust steam and therefore promotes heat losses. It is questionable whether such losses would be very serious in practice, but in order to minimise them the part of the turbine which is enveloped with exhaust steam is covered with a thin steel casing which, of course, serves to insulate the hotter metal from the steam at a lower temperature which surrounds it. Fig. 29 gives a good idea of the simplicity of the castings which form the turbine casing. They are obviously unlikely to give trouble from distortion by heat and are designed with a view to ease of manufacture. By referring to Figs. 28 and 29 it will be noticed that the halves of the casing are devoid of flanges, but are held together by long studs, the bosses for which are cast on the casing at some distance from the joint. This not only enables the studs to be got very close in to the work, but also avoids the distortion troubles which thick flanges are liable to give rise to. The pull of the studs is transmitted well to the body of the casing, there is plenty of room for their nuts, and a tight and effective joint of the turbine casing is obtained.

The turbine rotor runs in two plain bearings. The journal blocks as we have already mentioned act as nuts to hold the rotor together. The outer end of each journal block is bolted to one side of a flexible diaphragm coupling, the other side of which is fastened to a hollow shaft running through the centre of the first gear pinion. These hollow shafts are connected to the outer ends of their respective pinions through other diaphragm couplings, so that the drive between the turbine and the pinions is thoroughly flexible. The arrangement not only relieves the turbine rotor shaft and bearings from any appreciable streases due to want of alignment, but it enables the high speed pinions to remain always in perfect contact with the wheels they drive. Very great care has been taken to ensure that the axes of the pinions and second motion gear wheels shall remain parallel under all circumstances, and to the attention which has been paid to this point must no doubt be attributed the silence and smoothness with which the gear works. The scheme will be better understood when the whole lay-out and design of the gearing is considered later.

There is, of course, no need for a governor on the turbine in the ordinary sense of the word, as its speed is regulated by hand in accordance with the desired speed of the train. It is, however, fitted with an emergency governor which shuts it down if the speed exceeds a predetermined amount. This device can be seen on the exhaust end bearing, in Fig. 27, but is shown separately to a larger scale in Figs. 37 and 38, on Plate XIII. Encircling the end flange of the journal is a steel ring, like a piston ring except that it is symmetrical and uncut. Between the ring and the shaft at one point—the top, in Figs. 37 and 38—is a small stirrup clip which is of such a thickness as to keep the ring concentric with the shaft. At opposite ends of the horizontal diameter in Fig. 38 will be seen two thin struts, the inner end of each resting in a notch formed in the shaft, and the outer end in a notch in the inner face of the piston ring. The action of these struts is to cause the ring to rest firmly on the clip above mentioned, so that the ring is located

TURBINE-DRIVEN LOCOMOTIVE: ARRANGEMENT OF REDUCTION GEARING.

CONSTRUCTED BY THE AKTIEBOLAGET LJUNGSTRÖMS ANGTURBIN, ENGINEERS, STOCKHOLM.

Fig. 42.

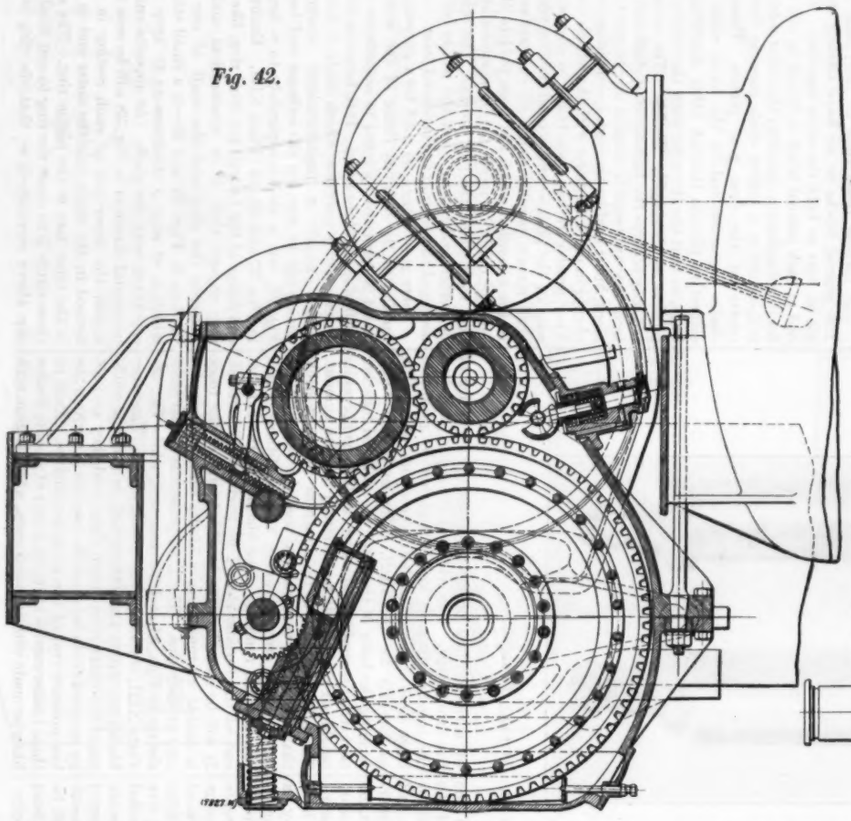
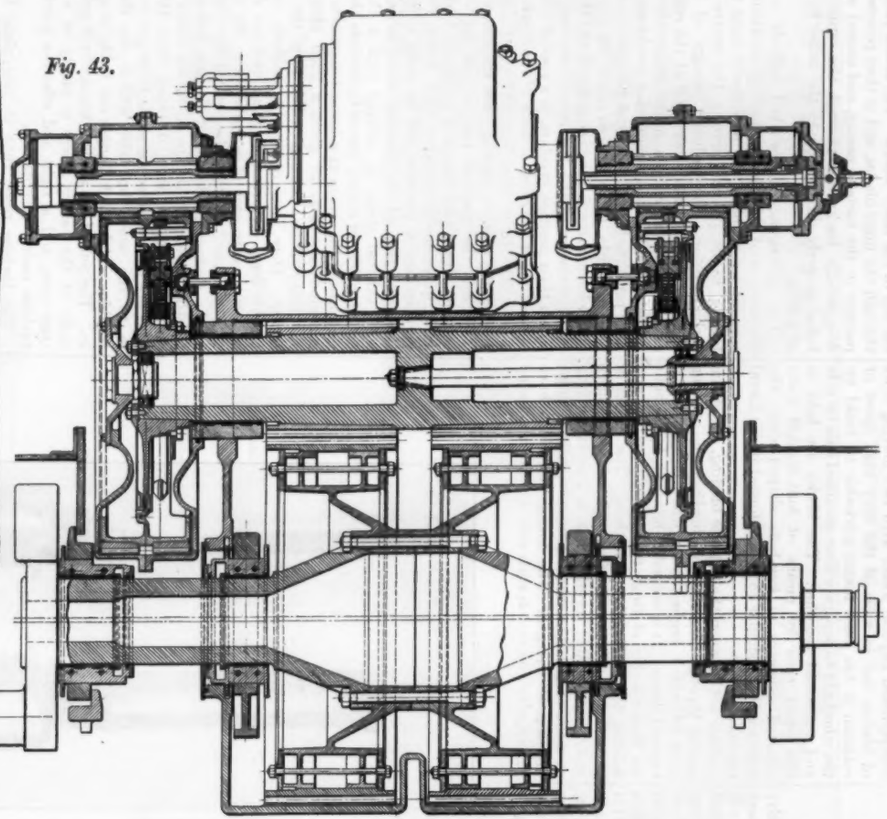


Fig. 43.



concentrically with the shaft by three points. The longer stout pegs shown near the struts are to prevent endways motion of the ring along the shaft. The ring is in perfect balance, except for the centrifugal force developed by the small clip. At a given speed this causes it to become distorted, so that its outer face comes in contact with the plunger shown. This causes the balanced piston, above, to open an oil port, which at once relieves the oil pressure holding the nozzle valves open, as will be understood by reference to Fig. 27. These valves are immediately closed by their respective springs, and the turbine stops.

THE GEARING FOR THE TURBINE.

The drive from the turbine-shaft to the locomotive wheels takes place through double reduction gearing, having an overall ratio of practically 22 to 1. The maximum speed of the turbine-shaft is 9,200 r.p.m., the final gear-shaft and therefore the driving wheels then rotating at 420 r.p.m., giving a locomotive speed of 110 km. (68 miles) per hour. The general arrangement of the gearing is clearly shown in Figs. 42 and 43, annexed. At each end of the turbine spindle is a double helical pinion driven, as previously mentioned, through a pair of flexible couplings. These pinions mesh with the teeth of wheels situated at the ends of the second motion-shaft, and a broad pinion occupying the central portion of this shaft engages with the final gear wheel on the jack-shaft. The whole of the gearing is of course totally enclosed. The turbine is constructed for running only in one direction, and the manner in which the locomotive is reversed will be described later.

The arrangement of the high-speed pinions at the ends of the turbine is shown in Fig. 27, while a photograph of one of these pinions is reproduced in Fig. 31, Plate XIV, and details of its construction are given in Figs. 32 and 33. The design is particularly interesting in view of the method adopted to procure a certain amount of flexibility for the teeth. The latter are cut in the ordinary way, and then the metal between the teeth is removed to a depth considerably greater than the pitch of the teeth, so that the latter form the tops of comparatively thin metal walls. The metal is cut away in one operation by a small formed milling cutter operated like a slot mill, its axis being vertical to that of the pinion. Previously to deciding to employ teeth rendered flexible in this manner, Mr. Ljungström tested dummy teeth embodying the same principle, to destruction, and thus secured data as to their resistance to fatigue, due to continuous reversals of stress. These experiments gave ground for confidence that the principle could be safely adopted, and experience, so far, has justified this conclusion. The amount of tooth flexibility required is exceedingly minute, yet some is necessary to ensure the equalisation of pressure along the whole length of the teeth in contact.

One of the wheels into which these high-speed pinions gear is shown in Figs. 39 to 41, on Plate XIII, and in section to a larger scale in Fig. 27. It will be noted that a spring drive is provided between the rim and the boss. Three powerful leaf-springs are pivoted from pins in the rim by clips which embrace the ends of the springs. The centre part of each spring is surrounded by a clip, rollers projecting from which engage with the internal corners of a triangular frame fixed to the boss. It will be evident that any rotation of the boss relatively to the rim is resisted by the stiffness of the plate springs, and thus a yielding drive is obtained. The friction between the leaves of the springs

exercises a damping effect and prevents torsional or other oscillations. The function of a spring drive at this point is to prevent shocks on the high-speed gearing due to the effect of the final crank and coupling rod drive. The torque of the turbine may be taken as absolutely constant, but the resistance of the train which has to be overcome is transmitted back to the turbine through the coupling rods connecting the jack-shaft to the driving wheels. There is a reversal of stress in each of these rods twice during each revolution, and as a working amount of clearance is, of course, necessary at the crank pins, the effect of the stress reversals is to produce a certain periodic irregularity in the relationship between the speed of the gearing and that of the road wheels. This irregularity is of course very small indeed, but it is quite sufficient to cause trouble with the high-speed gearing unless provision is made to neutralise its effect. Hence the spring drive we have described was introduced, and it appears to fulfil its functions quite satisfactorily.

The casing of the gears is shown in Figs. 44 and 45, Plate XV. There are really three separate casings, one enclosing each of the high-speed pinions and the wheel into which it meshes, and the other main casing enclosing the large final drive. The reason for dividing the casing in this way is to get rid of all strains and distortion effects which would interfere with the perfect running of the gears. Experience with double-reduction marine gearing has abundantly shown the necessity of preventing any measurable lack of alignment of the teeth of these high-speed and heavily-stressed wheels. Were the casing all in one piece, not only would accuracy of machining be difficult, but there would be a liability to unforeseen distortions arising from temperature effects or stresses set up by working. The way in which the casings of the high-speed gears are constructed and mounted will be seen in Figs. 27 and 43. Each side casing carries the bearings for its high-speed pinion, and is itself carried on a self-aligning ball bearing from the centre of the second motion shaft. It is connected to the main central casing by a number of spherical-headed links. As will be seen, the casing is practically unconstrained, and the high-speed pinion is therefore free to set itself into alignment with the spring wheel which it drives. The central shaft shown attached to the web in the middle of the second motion pinion, has nothing to do with the gearing, but is employed to drive the fans for circulating air through the condenser. The jack-shaft which carries the final gear drive, terminates in cranks to which are attached the ends of the coupling rods connecting the driving wheels. The bearings for this shaft are not formed in the casing itself, but are carried in heavy levers fulcrumed about a centre directly underneath the end of the condenser. The object of this is to enable the reversing of the locomotive to be effected.

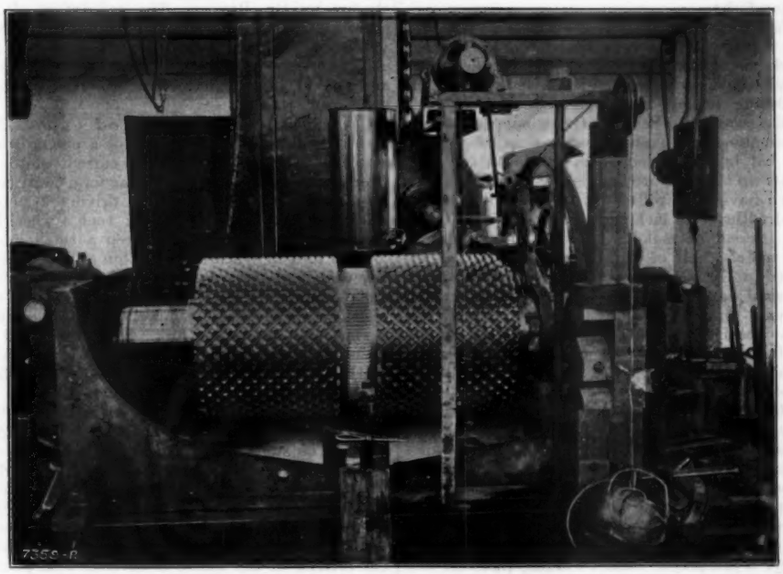


FIG. 56. IDLER WHEEL UNDER CONSTRUCTION.

THE REVERSING OF THE LOCOMOTIVE.

As the turbine is designed to run in one direction only, it is evident that some provision has to be made in the gearing for reversing the motion of the locomotive. The way this has been done is a particularly bold example of engineering. Reversal is effected by inserting an idle pinion between the pinion and wheel of the last drive. The large wheel is dropped slightly, so as to disengage its teeth from those of the pinion which normally drives it, and the idle pinion is then moved radially into position so as to gear with both. A moment's reflection will show that any wheel which has to gear with both members of a pair of helical gears must have teeth running spirally in both directions. The idle wheel used in the present instance is a case in point. Its appearance is shown in Fig. 56, where it is seen in course of manufacture. Owing to the doubling of the spirals the teeth, of course, only have about half the normal bearing surface for an ordinary pinion of equal width, but as the idle wheel is only in use when the locomotive is running backwards, this point is of no importance.

The sequence of operations involved in reversing is as follows. Oil pressure is first admitted behind the spring-controlled piston shown housed in the right-hand side of the casing in Fig. 42. The mechanism is shown to a larger scale in Figs. 46 to 49, on Plate XV. The piston moves slightly forward carrying with it a pair of partial wheels mounted on a pin held in a forked end. A hole is bored radially through the rims of these partial wheels, being half in one rim and half in the other as shown in Fig. 47. Small springs normally keep the rims in such a relative position with respect to each other and to the plunger upon which the piston acts, that when oil-pressure moves the piston forward until the wheels are stopped by any obstacle, the plunger can continue its forward motion by passing into the hole mentioned. This is what happens, supposing the gears at rest when the partial wheels are moved forward so as to touch the pinion, but if the gears are not at rest, the partial wheels are rotated by them as soon as contact is established, and the plunger cannot enter the hole. In this event nothing more happens and the driver is unable to do anything further. Should the gear be at rest, however, the plunger can move forward under the oil pressure until a port is opened through which the oil pressure is transmitted for the next step in the work of moving the gear. This step consists in unlocking the gear so that it may be moved. The oil enters the small cylinder shown adjacent to the idle wheel, in Fig. 42, and moves a spring-controlled plunger to which a rack is attached. The motion of the rack rotates a stop shaft which lies in a groove on the circumference of a disc. Normally the shaft holds the disc from rotating, but when a flat on the shaft comes round far enough, the disc is no longer held, as the flat provides clearance for its rim to pass the shaft.

The gear having been unlocked in the manner described the oil is then able to act upon the lower large plunger shown on the left-hand side of Fig. 42. This plunger is driven downwards by the oil pressure and the rack attached to it rotates the quadrant seen in the illustration. This causes the rotation of a cam disc which works between rollers fastened to the end of jaws of a heavy steel lever pivoted at the other side of the casing. The rotation of the cam causes the descent of the lever, and as the latter carries the bearings of the large gear wheel this wheel is dropped out of gear with its pinion. Pivoted to the cam is a connecting rod, which brings the idle wheel into mesh both with the pinion and the large gear wheel, as the cam is rotated. The gear is then in the position shown in Fig. 42. The release of the oil pressure causes the locking piston to return under the action of its spring, and the whole arrangement is locked in its new position.

In spite of the apparent complexity of the series of motions involved in reversing the locomotive the operation can be carried out quite as rapidly as on a locomotive of the ordinary type. The driver has only to move one small handle and all motions then take place in the necessary sequence. Until the gear is at rest nothing can happen. Moreover, until it is again locked in one position or the other it is impossible for steam to be admitted to the turbine. Hence everything is as safe as it can well be, for the failure of any one of the motions will prevent the locomotive being started. It is, of course, just possible that when the idle wheel is presented to the pinion and main gear wheel, in reversing, the extreme tips of the teeth will come into contact, and the idle wheel will thus refuse to enter into gear. In such a contingency the driver takes hold of the handle shown at one end of the turbine shaft and moving it slightly inwards, engages it with the shaft by means of a small ratchet clutch. The turbine can then be rotated by means of the handle, one or two strokes of which will alter the position of the gear sufficiently to enable the idle wheel to become enmeshed.

The controlling gear of the locomotive is illustrated in Figs. 50 to 55, Plate XV. As all the work of opening nozzles and reversing the locomotive is done by oil pressure, the duties of the driver, so far as control is concerned, are confined to operating small handles which direct the flow of the oil. The larger of the two handles shown in Fig. 51 effects the distribution of oil to the nozzle valves, any number of which up to the maxmium of five may be used at the desire of the driver. The smaller handle controls the oil to the reversing gear which has just been described.

(To be continued.)

THE NATIONAL PHYSICAL LABORATORY.

(Continued from page 122.)

Electricity Department (Principal Assistant, Dr. E. H. Rayner, M.A.). *Electrical Standards* and *International Units* (Messrs. D. W. Dye, L. Hartshorn and R. L. Smith-Rose).—Of the six international ohm coils, which were sent abroad for comparison, the two which had gone to Paris proved erratic and had evidently suffered in transit. The unit of the Bureau of Standards is by 19 parts in 1,000,000 smaller than that of the Laboratory. There has been no absolute redetermination of the ohm by the Lorenz apparatus. The determination of the ohm by the Carey-Foster bridge and the Maxwell commutator bridge differed by more than 1 in 10,000 from the accepted value of Mr. F. E. Smith, and there was some doubt as to the

correctness of the Laboratory standard of mutual inductance; but this standard seems to be correct, and in the redetermination the Maxwell bridge is not to be used.

Magnetic Work.—When magnetic ballistic tests have to be conducted in very low fields, an exact compensation of the earth's field is required. For this purpose a cubical frame of 1 m. side-length has been constructed, having three Helmholtz windings in planes mutually at right angles; the number of turns on these is such that a particular current sent through the three coils in series will balance the terrestrial field.

Radio-Standards of Inductance, Capacity, Frequency. Quartz Insulators.—An Abraham-Bloch multivibrator with a fundamental frequency of 1,000 cycles per second has been constructed to serve as primary standard for frequencies up to 150,000 per second; the fundamental frequency of 1,000 is, as was first done in the Laboratory, controlled by means of a valve-maintained tuning fork. When the standard air condensers were being constructed, Mr. Dye examined the reliability of amber and of quartz as insulating materials at high frequency. In the case of amber, a small pot with very thin walls was very carefully machined out of amber, the pot was filled with mercury and placed in a mercury basin; the capacity, direct-current leak and dielectric hysteresis at radio-frequency of this condenser were determined. Similar tests made on a bulb blown of clear quartz glass showed the decided superiority of the quartz.

As a result, the amber washers in standard condensers are being replaced by washers of clear transparent quartz, which have to be about 1 cm. in thickness, however, to bear the stress of binding screws, etc. The work on the radio-standards also comprises experiments on the separation of the power losses in air condensers from those in the inductance coils in the oscillatory circuits. On the effective resistance of coils at radio-frequencies and on the capacity and eddy current effects in inductometers, Mr. S. Butterworth, who has lately left the Laboratory, has presented papers of great value to the Royal Society and the Physical Society.

Standard Air Gap. Optical Lever for Thickness Measurement.—Among the novel apparatus, demonstrated on the inspection day, was a standard air gap for dielectric tests of mica and thin-sheet materials (about 0·1 mm. in thickness). The apparatus consists of three steel plates; on the base plate rest a smaller plate and further three pillars, about 1 cm. high, of quartz (made by Messrs. Hilger), so supporting the third plate that an air gap, about ¼ mm. thick, is left between the second and third plates; all the surfaces are carefully planed. The sheet to be tested is placed in the gap, and capacity measurements are taken with and without the specimen in position. The method is more reliable than when the mica is provided with coatings of tin foil, which are never in perfect contact. But the thickness of the sheet mica is itself an uncertain and yet important quantity. For the thickness determination, Mr. Dye further makes use of his optical lever. The device consists of a steel disc into which two steel spheres are let; half-way between them, and not quite in alignment with them, is a steel pin, 1 mm. in diameter. Over the disc is placed a steel bar having three steel spheres let into its lower surface, these three spheres occupying positions corresponding to those of the two spheres and the pin fixed in the disc. When the specimen is inserted between the central ball and the pin, the bar rocks, and a mirror attached to it throws the reflected light spot of a lamp on a fixed scale on which readings to 0·001 mm. can be taken.

Radiotelegraphy, Screening Oscillators.—We have on other occasions mentioned Mr. R. L. Smith-Rose's experiments on determining the direction of the source from which signals are arriving and the as yet unexplained unreliability of some of these observations, especially at night time. The direction-finder so far used had been worked with damped waves. The experiments are now made with continuous waves, but the difficulties of protecting the receiving apparatus against disturbance by the local triode oscillators becomes very great, especially with long waves of 10 km. and more. Electrostatic interference can be prevented by surrounding the body (electrified or to be protected) with a metal covering the thickness of which is immaterial and which may consist merely of wire-gauze (a Faraday cage). The electro-magnetic screening must be much more perfect. The smallest hole or crack in the cage will allow a detectable amount of the high-frequency energy to escape. Mr. Smith-Rose found that the valve set should be placed within a metal box, or an inner box encased in an outer box, made of sheet metal of a thickness suitable for the wave-length used. The joints in the box and lid should be hermetically sealed and soldered or welded; the outer box is conveniently inverted so as to stand in a mercury tray. The wire connections of the circuits are brought out through telephone plugs, passing through the covers. Iron is preferable to copper as box material to prevent direct penetration of the waves.

In measuring the strength of the received signals, Mr. Smith-Rose makes use of an Einthoven string galvanometer with photographic recorder, so arranged on a valve circuit that the steady anode current is balanced out by a potentiometer. A phonic-wheel for telephonic frequency work is under construction; it is to be self-starting and self-synchronising by the aid of triode valves, and to be used in the first instance for calibrating tuning forks.

High-Frequency Ammeter-Inductance Coils.—The new high-frequency ammeter of Mr. F. M. Colebrook, is of the thermo-junction type. Ten (or more) copper stampings of L shape, separated by insulating washers, are mounted to form a block. In the recess lies, between spring supports, a bar of ebonite carrying the heater strip of copper; this bar being levelled by means of two screws; higher up the gaps are bridged by 10 eureka wires, which have been rolled out to a width of a few hundredths of an inch and to a thickness of 0·005 in. Instead of making the thermo-junctions of two metals, half of each eureka strip is copper-plated, as Mr. Hamilton Wilson described to the Physical Society two years ago. Owing to their extreme thinness, eureka strips have a very low heat capacity and can hence respond very rapidly to slight changes when thermo-electric forces are to be measured. Another novelty of Mr. Colebrook's is a special type of inductance coils for 2,000-volt valve generators. These coils should have a minimum capacity of 0·5 kw., a very concentrated field, and a high ratio of inductance to resistance at radio-frequency. For inductance values up to 0·3 millihenry, two, three or four layers of copper strip spirals of 30 cm. external diameter, are wound on an ebonite frame, spaced 0·5 cm. apart. For higher values up to 3 millihenry, a multilayer basket-winding (internal and external diameters, 24 cm. and 30 cm.) is adopted, with gaps of 15 mm. between the layers; the coils consist of 81 stands of No. 40 silk-covered wires. This combination of coil layers in basket fashion is much less expensive than condensers would be.

Electrotechnics. Alternating Currents (Dr. Rayner, Mr. R. Spilsbury)—The work in this department is much hampered by the want of a duplicate generator plant. Electrical manufacturers have so far not shown any readiness to undertake special work of this nature, and the Siemens-Schuckert set transferred from the Board of Trade is of small output and, moreover, unsuitable for a large proportion of the tests, because its wave form deviates too much from the sine type. Three new current transformers, each of 4,000 amperes, have been put up.

The present high-voltage equipment was installed ten years ago. The 100,000 volts actually available are inadequate, even for testing 66,000-volt installations, and it has to be borne in mind that 200,000 volts are being approached in other countries. Enquiries have been made as to the cost of equipment for 300,000 and 500,000 volts; such apparatus would require a building of special design, but would also be of high value for the Physics and Radio Departments.

Wattmeters.—The precision electrostatic wattmeter showing a slight peculiar sensitiveness to temperature, the quadrants were made of invar instead of steel. That had little effect, however, and it was demonstrated that the verticality of the internal main wall of the building changes with temperatures owing to the stresses produced by the roof tie-rods or the guttering, though the instrument does not operate like a seismometer. There is also a pendulum effect in the high-voltage wattmeter, likewise of the electrostatic quadrant type, specially designed for measuring the power absorbed in insulation at potentials up to 100,000 volts. The moving parts are immersed in oil, and any radial dissymmetry, which cannot entirely be prevented, tends to draw the system sideways. In order to estimate this force, a model was constructed, with which Mr. Dye performed capacity experiments at a frequency of a million per second, when the needle was moved from the centre in different directions. Another problem, studied by Mr. Butterworth, was how to lead the high-volt connections to the needle through the openings in the centre of the quadrant system; the problem is the same as that of taking a cylindrical conductor through a hole in a conducting wall, when the diameter of the conductor and the rounding of the edges of the hole should bear a certain relation to the diameter of the hole. The use of this wattmeter, with the aid of which an extensive investigation of the properties of a large variety of insulating material is to be conducted for the Electrical Research Association, was, on the day when the annual visitation took place, demonstrated by Dr. Rayner. The description of the electrostatic voltmeter, which we mentioned last year [Engineering, August 5, 1921, page 212] has called forth enquiries from America and Japan, and the Laboratory has constructed six of these instruments.

Continuous-Current Motor Speed Control.—Mr. Spilsbury demonstrated the use of a phonic wheel motor for keeping a continuous-current motor as steady as a tuning fork. The tuning fork, electrically maintained in oscillations, was driving a phonic wheel motor at a definite speed; such a wheel has sufficient power available to keep a small motor coupled to it in synchronism within quite a reasonable change of load. When, therefore, the motor is run at approximately the speed of the wheel, the wheel, acting as motor or brake, will keep the motor in time with the tuning fork. This device will be useful for governing the speed of rotating apparatus which require more power than the phonic wheel can supply directly.

Photometry (Dr. Rayner, Messrs. J. W. T. Walsh, H. Buckley, Taylor). *Integrating Sphere Photometer.*—The submarine mine case, made of ¼-in. steel, 3 ft. in diameter, which has been converted into an integrating sphere photometer, was mentioned last year. The two hemispheres of the case are bolted together, and there is a translucent window, 3 in. diameter, in the equatorial plane. The interior of the sphere is covered with plaster painted white with a matt surface. The lamp under test is lowered into the sphere through a hole at the top, and the brightness of the window, which receives the reflection from the surface, is measured while the direct lamp beam is screened off. That the sphere fulfils its purpose has been demonstrated by experimenting on a lamp having the vertical half of its bulb blackened; the brightness of the window should not, and did not, alter when the lamp is turned about its vertical axis.

Ship's Navigation Lamps.—A report on ship's lamps has been presented to the Board of Trade. It is proposed to issue sets of coloured-glass standards to be compared with the master standards at the Board of Trade and the Laboratory. There is no difficulty about red glass; copper, gold and selenium glasses give, in suitable thickness, nearly identical transmission factors for different parts of the spectrum, as measured by spectro-photometer and a thermopile. But the green glasses do not cut out the yellow and orange as satisfactorily as the red cut out the yellow and green, and with a transmission of 25 per cent. of the light (quite safe for red), so much yellow gets through the green, that, in certain states of the atmosphere, the green may appear white. The lamp lenses recommended in the Report, are the outcome of trials rather than of design. As regards motor-car headlights, the authorities do not seem to be able to make up their minds; the public hardly understands why the glare nuisance cannot be suppressed.

International Commission on Illumination. Lighting of Factories and Public Buildings.—The International Commission on Illumination, on which

Dr. Rayner and Mr. Walsh were the British Delegates in 1920, at Paris, will meet again in New York, in 1924, the most important subjects for discussion being international standards and heterochromatic photometry and, next to these, nomenclature, and factory and automobile lighting. A report on factory lighting has been presented to the Home Office by the Laboratory; in the tests, daylight, artificial light and mixtures of the two were compared. Dr. Rayner's investigations of the best illumination for the National Gallery were noticed last year; they have quite recently been brought before the Illuminating Engineering Society. He studied the problem by making a model, and a house, so far resembling a glasshouse, 60 ft. by 30 ft. by 17 ft., has been erected in the Laboratory grounds for the further investigation of the lighting of public buildings.

Direct Current Work (Messrs. S. W. Melsom, H. C. Booth, S. D. Anderson). *Buried Cables.*—Most of the important work done in this division for the British Electrical and Allied Industries Research Association remains in the confidential stage, the reports having not been published yet, even if complete in part. The work on buried cables research involves testing the effects of grouping cables and of intermittent loading, determination of the data for the production of load tables for cables of all sizes with various thicknesses of insulation when buried direct in the ground (these load tables are now ready), determination of dielectric losses in extra-high tension cables and the effect of 3-phase loading as compared with direct-current loading. Most of the, partly big, novel apparatus wanted for this research have been designed and constructed in the Laboratory. Such are, *e.g.*, the special loading transformers—which, though they themselves step only from 100 volts down to 10 volts (and 500 amperes), have to bear the 60,000-volt currents superposed during the tests. These transformers are iron tanks filled with oil; the primary circuits are of the ordinary kind; the secondary windings are simply rigid bare spirals of copper strip, standing clear of the primaries, being insulated from them by the oil, and attached to an upper insulation bar by bolts which serve as tapping points. The cables have further to be tested in thermostat ovens for deterioration of the dielectrics by high temperature. The regulator which keeps the temperature steady, consists of a stout bimetallic spiral and an adjustable screw inside the oven; one end of the spiral is fixed to a spindle, which emerges through the roof of the oven, so that the whole force of the spiral is exerted on the spindle; the pointer and scale are outside, on the top of the box. The insulation tests are conducted in conjunction with the Heat Department. The research on ship's cables is Admiralty work.

Fuse Testing. Meter Types.—The fuse tests are made in conjunction with the Alternating Current Section. The fuses are short-circuited on batteries, an oscillograph recording the transient amperes, volts and a time scale. Much further work will have to be done on fuses; but it is clear that the accepted values of the peak currents flowing when fuses melt are much too low. Meter types are examined for approval on behalf of the Ministry of Transport; the work has, in the first instance, involved an inquiry into the various methods.

Joints and Contacts. Resistance of Alloys. Aluminium, Porcelain.—The research on the efficiency of joints and contacts, clamped, soldered and bolted on bus bars and of switch contacts is being continued. The manganin (ohmal) alloy has already been referred to in our notice of the work of the Metallurgical Department; one of the new standards of 0·01 ohm has not changed by 1 part in 100,000 in 18 months. As regards the resistivity of aluminium, the Laboratory, the Bureau of Standards at Washington, and the Laboratoire Central d'Electricité are collecting data for establishing an International Standard for aluminium wire. Hard and soft specimens, of ordinary and special purity, have been prepared by the British Aluminium Company for exchange. The resistance of porcelain for sparking plugs, furnace tubes, etc., is being investigated at temperatures up to 1,200 deg. C.; special electrodes and furnaces are required, and the elimination of polarisation effects is very difficult; we must bear in mind that galvanic gas cells have been constructed in which glass at high temperatures serves as "electrolyte."

Universal Multi-Range Ammeter Shunt.—On the inspection day some of the arrangements made in the laboratories and in the cable huts for the cable tests could be seen, and Mr. Melsom also demonstrated the use of the universal ammeter shunt, for large ranges of current, of the Ayrton-Mather type, which is more appreciated in Germany and America than in this country. Two sets of boxes are used, for ranges from 0·15 ampere to 30 amperes, and from 15 to 300 amperes; the switch brush overlaps two contacts, so that, in changing the range, the current is not interrupted.

Loan Store.—The loan store of various instruments and apparatus, set up on the suggestion of the Director and arranged like a library with a card index, has proved a valuable innovation; instruments are lent for two weeks.

(To be continued.)

GERMAN TORPEDO-BOAT DESTROYER BUILDING DURING THE WAR.

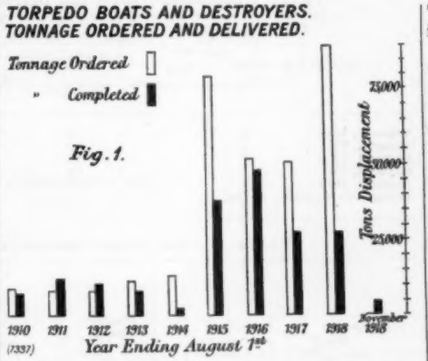
AT the later stages of the war Germany was concentrating on the building of two types of warships, namely submarines and surface torpedo craft. By far the greater energy was put into submarine production, but the building programme for torpedo boats and destroyers was quite formidable, as will be seen later. The reason for the concentration upon submarine construction is well known. The Navy demanded surface torpedo craft for the following purposes: Minelaying at a distance, submarine screens, the defence of the coasts of Flanders and the Baltic occupied by the German troops, and also to act as convoys for the sea traffic between Germany and Scandinavia. These vessels were also adapted for mine-sweeping and for general anti-submarine work. As the war progressed these duties developed, and demands were made for faster and more seaworthy vessels.

The order in which the torpedo craft were ordered and built is of considerable interest. The boats on order in August, 1914, were all of a medium type, including V. 43 to 46, G. 37 to 42, and S. 49 to 52. In addition, larger boats were building for foreign Governments. Krupps Germania Werft, at Kiel, was building four destroyers of over 1,500 tons deep displacement for Argentine; these were taken over by the German Admiralty and re-named G. 101 to 104. Blohm and Voss and the Vulkan Werft, at Hamburg, were each building two large destroyers of 1,700 tons deep displacement for Russia; these also were commandeered by the Germans and re-named B. 97 and 98, and V. 99 and 100 respectively. Up to the outbreak of the war the German Admiralty had confined its surface torpedo craft construction to three firms only, viz., Krupps, Germania Werft at Kiel, Schichau Werft at Elbing, and the Vulkan Werft at Stettin. The boats from these shipyards can be readily distinguished by the letters G., S. and V. which precede their number. With the increased requirements due to the war the two last-named firms also utilised their yards at Dantzic and Hamburg respectively for this work and, in addition, firms quite new to the work were employed, and built largely under the guidance of the three firms previously mentioned. For example, Howaldts, at Kiel, built destroyers identified by the letter H., with the assistance of the neighbouring Germania Shipyard of Krupps. Other shipyards built the hulls only, which were towed from Lubeck and Rendsberg to the Schichau or Vulcan yards to have the machinery installed and be completed ready for trials. The only Imperial yard used was Wilhelmshaven, which received an order for a big destroyer right at the end of the war, but had hardly commenced work on it, when the armistice was signed. Each new shipyard was supplied with drawings and expert advice from the three original specialists in this work.

At the end of 1914 some 84 torpedo craft were ordered or building, and all were to be fitted to burn oil fuel. The cutting off of the fuel oil supplies usually obtained from Galicia and Roumania brought the fuel problem to a head immediately. Efforts were made to alter the boilers so that they could burn coal. The tar oil which had to be consumed necessitated the use of special burners. This fuel difficulty considerably hindered production in the first year of the war.

TABLE I.—OUTPUT OF TORPEDO-BOATS AND DESTROYERS—AUGUST, 1914, TO NOVEMBER, 1918.

Firm.	Shipyards at.	Boats Ordered.	Tonnage.	Boats Delivered.	Tonnage.
Vulkan	Stettin and Hamburg	138	110,760	88	58,505
Schichau	Elbing and Dantzic	109	95,780	79	49,362
Krupps	Germania, Kiel	28	37,834	22	27,046
Howaldts	Kiel	27	35,819	2	2,266
Blohm and Voss	Hamburg	9	18,129	6	10,740
Imperial Yard	Wilhelmshaven	1	1,133	—	—
	Total	312	299,455	197	147,919



It is now proposed to summarise the output of these craft by the German shipyards during the war. Actually between August, 1914, and November, 1918, some 197 torpedo boats and destroyers were completed for service. Of these 100 were of the large or destroyer type, leaving 97 of the smaller coastal torpedo-boat type. In addition, when the war ended, another 115 were building or on order. Thus the total number of this type of war vessel which had been built or ordered was 312. To assist the output, it was arranged that the two or three principal shipyards building these torpedo craft should not build U-boats. Accordingly Schichau Werft, at Dantzig, and Vulkan Werft, at Stettin, did not build a submarine, and Schichau, Elbing, only started U-boat building right at the end of the war, and did not complete one of the few small submarines it had in hand.

The output of torpedo boats and destroyers was hindered by the following: (*a*) The shipyards as a whole were overweighted with U-boat construction. (*b*) Men were taken away for the army. (*c*) The output per man diminished steadily as the fit men were gradually replaced by men not fit for army service. (*d*) Scarcity of raw materials and fuel, accentuated by the transport difficulties. As regards (*d*) it is stated that ordinary steels had to be used in place of the scarce high-strength steels, with a corresponding increase in the scantlings and the weight of the hull.

In spite of these difficulties the two principal builders, Vulkan and Schichau, completed a large number of these torpedo craft, as will be seen from Table I. The tonnage figures given in this table are the deep load displacement figures, with the vessels carrying their maximum amount of fuel and complete with all stores, &c.

Table II gives in detail the boats completed by each builder, together with the dimensions, horsepower, speed and armament, as well as the date

TABLE II.—DETAILS OF TORPEDO BOATS AND TORPEDO BOAT DESTROYERS BUILT IN GERMANY DURING THE WAR.

Boats.	Date of Order.	Time to Build 1st Boat, in Months.	Length Metres.	Breadth Metres.	Draught Metres.	Legend Displacement. Tons.	Oil Carried. Tons. Normal.	Oil Carried. Tons. Maximum.	H.P.	Speed. Knots.	Armament. Torpedo Tubes.	Armament. Guns.	Mines.
SCHICHAU-ELBING AND DANTZIC.													
S. 31 to 36	April, 1913 ..	12½	79·6	8·3	2·39	790	90	220	22,180	34·9	Two single, two double 50-cm. tubes	Three 8·8 cm.	24
S. 49 to 52	August, 1914 ..	10	79·6	8·3	2·39	790	90	250	24,610	37·1	,, ,,	,, ,,	24
S. 53 to 66	August, 1914 ..	8	83·3	8·3	2·53	905	162	305	25,013	35·7	,, ,,	Three 10·5 cm.	24
A. 26 to 49 ..	December, 1915 ..	6	50·1	5·3	1·83	228	45	53	3,500	26·3	One 45-cm., single	Two 8·8-cm. ..	nil
A. 50 to 55 ..	July, 1916 ..	4½	50·1	5·6	1·84	229	45	55	3,500	25·7	,, ,,	,, ,,	nil
S. 131 to 139 ..	July, 1916 ..	8	83·0	8·3	2·55	910	162	305	24,000	34·6	Two single, two double 50-cm. tubes	Three 10·5-cm.	nil
A. 67 to 79 ..	July, 1916 ..	5½	60·0	6·4	1·9	354	76	82	5,800	27·0	One 45 - cm. single	Two 8·8-cm. ..	nil
A. 92 to 95 ..	July, 1917 ..	7	60·0	6·4	1·9	354	76	82	5,800	27·0	,, ,,	,, ..	nil
VULKAN—HAMBURG AND STETTIN.													
V. 25 to 30 ..	April, 1913 ..	7½	78·5	8·3	2·68	800	90	232	24,300	38·2	Two single, two double 50-cm.	Three 8·8 cm.	24
V. 43 to 46 ..	April, 1914 ..	9½	79·6	8·3	2·73	831	90	280	25,400	37·5	,, ,,	,, ,,	24
V. 47 and 48 ..	April, 1914 ..	12½	83·1	8·3	2·84	948	179	338	23,850	35·3	,, ,,	Three 10·5-cm.	24
V. 67 to 84 ..	August, 1914 ..	9	82·0	8·3	2·8	950	160	317	22,600	36·6	,, ,,	,, ,,	24
V. 105 to 108 ..	August, 1914 ..	12	61·0	6·2	1·9	349	30 coal 5 oil	60 coal 16 oil	6,000	30·1	Three 45-cm. single	Three 8·8-cm...	12
V. 99 and 100 ..	August, 1914 ..	7½	99·0	9·36	2·81	1,313	150	519	42,850	37·8	Two single, two double 50-cm.	Four 10·5-cm...	24
A. 1 to 25	September, 1914 ..	3	41·6	4·6	1·26	107	—	24	1,125	20·0	Two single 45-cm.	One 5-cm. ..	4
V. 125 to 130 ..	June, 1916 ..	8½	82·0	8·3	2·79	907	167	330	25,500	34·7	Two single, two double 50-cm.	Three 10·5-cm.	nil
A. 56 to 66 ..	July, 1916 ..	6	60·0	6·4	1·8	329	85	91·7	6,050	28·3	One 45-cm. ..	Two 8·8-cm. ..	nil
A. 80 to 82 ..	March, 1917 ..	5											
A. 86 to 91 ..	July, 1917 ..	5											
KRUPPS—GERMANIA KIEL.													
G. 37 to 40 ..	April, 1914 ..	14	79·6	8·3	2·71	872	110	208	25,800	35·1	Two single 50-cm., two double 50-cm.	Three 8·8 cm. ..	24
G. 41 and 42 ..	April, 1914 ..	17	83·0	8·3	2·76	960	166	325	25,000	34·6	,, ,,	Three 10·5-cm.	24
G. 85 to 96 ..	August, 1914 ..	14½	83·0	8·3	2·76	960	166	325	26,300	34·2	,, ,,	,, ,,	24
G. 101 to 104 ..	August, 1914 ..	15	95·3	9·2	2·76	1,198	150	500	29,400	33·7	,, ,,	Four 10·5-cm.	24
BLOHM AND VOSS, HAMBURG.													
B. 97 and 98 ..	August, 1914 ..	4½	98·0	9·35	2·86	1,350	150	526	40,800	38·0	Two single 50-cm., two double 50-cm.	Four 10·5-cm.	24
B. 109 to 112 ..	October, 1914 ..	5											
HOWALDTS—KIEL.													
H. 145 and 146 ..	November, 1916 ..	16	85·3	8·35	2·84	990	166	330	23,800	33·5	Two single, 50-cm., two double 50-cm.	Three 10·5-cm.	nil

when each group was ordered. The third column gives the time which it is claimed was taken to build the first boat of each order. The legend displacement only allows for the normal fuel to be carried and at this draught the trial results given were obtained. The development in size and speed, as well as in offensive power, can be traced from these tables but this will be dealt with more fully later.

It has been stated that the output during the war was greatly increased, and this is shown very clearly by the diagram (Fig. 1). This indicates the tonnage ordered and delivered year by year from 1910 to 1918. The period covered is the twelve months ending on August 1 of the year noted. A statement showing the numbers and tonnage of the boats ordered and completed each year from the beginning to the end of the war is given in Table III.

In the first completed year of the war it will be seen that orders were placed for 60 destroyers and 29 torpedo boats. The destroyers included S. 49 to 66 from Schichau at Elbing, V. 67 to 84 and V. 99 and 100 from the Vulkan Yard at Stettin and Hamburg (where V. 99 and 100 were building for Russia), G. 86 to 96 from the Germania Yard at Kiel, and, in addition, G. 101 to 104 building at Kiel for the Argentine, were taken over. B. 97 and 98 were building by Blohm and Voss for Russia. Four more boats, B. 109 to 112, similar to B. 97 and 98, were ordered from the same firm. The commandeered boats as a whole were more powerful than the contemporary German Admiralty designs. The 29 torpedo boats ordered included V. 105 to 108, ordered from Vulkan, Stettin, and A. 1 to 25, ordered from the Vulkan Yard at Hamburg. This was the first order placed with the latter yard by the German Admiralty for torpedo craft.

These small A. boats, known as the "A.1" group, were built in nine months. The light displacement was only 100 tons and the armament two single 45 cm. torpedo tubes and one 5·2 cm. gun. The single propeller was direct driven and at 1,100 h.p. the speed obtained was 20 knots. Half of these boats were intended for the Flanders Coast. To avoid risk of capture they were transported in sections (after being erected and fitted up at Hamburg) by rail to Belgium, and were completed for service in the shipyards there. In a similar way some of the "A. II" group of torpedo boats were sent in sections by rail to Pola and erected in Austrian naval yard there. They were afterwards based on that port for service in the Mediterranean. It will be noticed that in the two years ending August, 1916, and August, 1917, considerably fewer boats were ordered than in the year immediately preceding and in the year immediately following this period. In the year ending in 1916 a large number of A. boats were ordered. They were larger than the A. 1 to 25 class, and were known as the "A. II" group. This class of torpedo boat was extensively used for anti-submarine work.

The increased horse-power required to meet the demands for higher speed, and greater endurance led to efforts being made to economise in the oil fuel consumption. Up to the middle of the war all torpedo craft had direct-driven propellers except V. 46, which was fitted with a Föttinger transformer as an experiment. This boat is stated to have had the maximum speed of her class. In the direct-driven propellers it is clear that the propeller efficiency was not good consequent upon the very high speed at which the propeller ran. Krupps Germania Yard claim the credit of first introducing mechanical reduction gearing into the German naval service. The first torpedo craft to have this gearing

TABLE III.—Torpedo Boats and Destroyers Ordered and Delivered, 1914–1918.

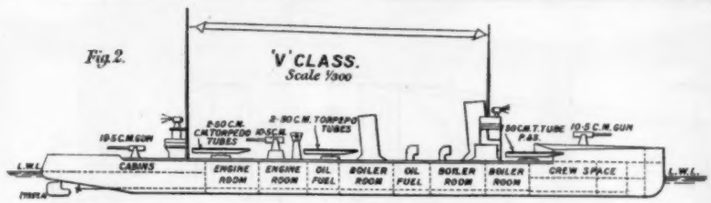
Year ending	Ordered. Destroyers.	Ordered. Torpedo Boats.	Approx. Total Tonnage.	Delivered. Destroyers.	Delivered. Torpedo Boats.	Approx. Total Tonnage.
August 1, 1914	12	—	15,000	3	—	3,000
August 1, 1915	60	29	80,000	25	29	37,000
August 1, 1916	20	48	55,000	42	—	48,000
August 1, 1917	37	22	56,000	15	38	27,000
August 1, 1918	54	18	90,000	16	24	27,500
August 1 to November 11, 1918	—	—	—	2	4	5,000

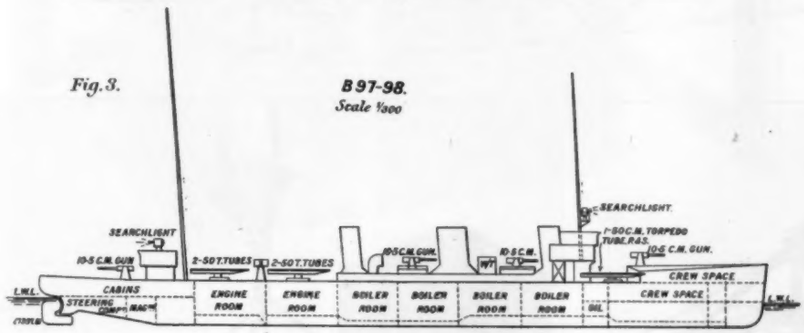
TABLE IV.—Ten Years' Progress in German Torpedo-Boat Destroyers.

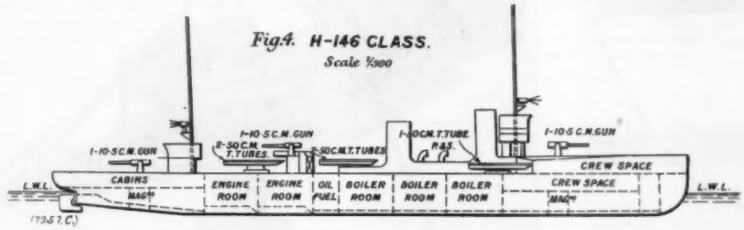
Date.	Boats.	Displacement.	Horse-Power. Designed.	Horse-Power. Actual Maximum.	Weight in Kilogrammes per Horse-Power. Designed. Engines.	Designed. Boilers.	Actual Maximum. Engines.	Actual Maximum. Boilers.
1907	V. 150 to 160	tons 555	10,250	i.h.p. 11,000	13·3	10·4	12·4	9·7
1917	V. 116 to 118	2,400	48,000	s.h.p. 56,000	7·8	6·6	6·7	5·7

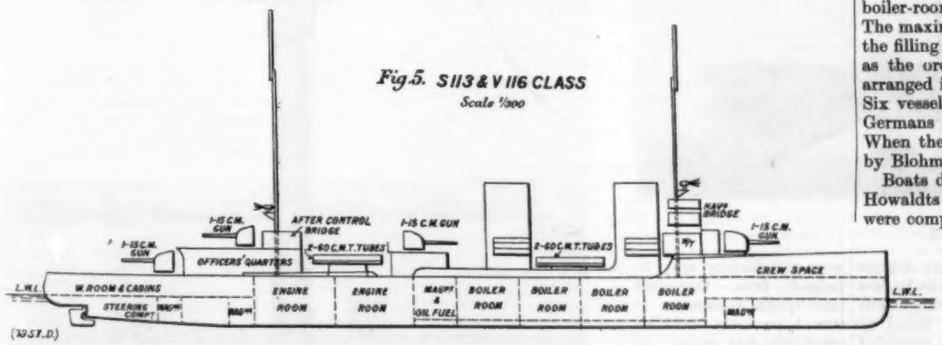
fitted between the turbines and the propeller shaft were A. 27 to 53, which were ordered in two groups, one in December, 1915, and the other in July, 1916. This reduction gear gave such good results that all designs in hand at the armistice provided for its use.

Blohm and Voss built six destroyers at the beginning of the war, and their record, of completing one of these in 4¾ months, is remarkable. On the completion of these six, the firm did not build another torpedo craft until the last year of the war, when three large destroyers were ordered and were well advanced when the war ended.









The increase in the coast line occupied by the German Army led to the demand for more torpedo boats for service on the Flanders Coast and in the Baltic. For this purpose the third group of A. boats known as the "A. III" class, were ordered. The yards engaged on the building were Schichau, Vulkan and Howaldts. The Schichau Elbing Yard completed their quota, but neither of the other yards had delivered any of these boats before the armistice was signed.

The size of the destroyer increased considerably, and the design produced in 1916 of a boat to carry four 15 cm. (5·9-in.) guns and two pairs of swivelling deck tubes to take 60 cm. (23·6 in.) diameter torpedoes, and to steam at 35 knots, represents the most powerfully armed torpedo-boat destroyer evolved at that time. Towards the end of the war it was decided to build still faster destroyers. The speed was increased by from 2½ knots to 3 knots and the displacement to 1,500 tons. These boats were fitted with mechanical reduction gear, but none of them were finished before the war ended.

It is interesting to notice that the uncompleted torpedo boat hulls, which could not be finished under the terms of the Peace Treaty have in certain cases been transformed and used for merchant ships. Some tankers have been completed recently, using the partially built hulls of torpedo craft. Four boats are named Erna David, Leopold David, Kosmos I and Wilbo. Their overall dimensions are: Length, 56·59 m.; breadth, 7·33 m.; draught, 5·5 m.; with a registered tonnage of 600. The ships are driven by two 300-h.p. heavy oil engines and the speed is anticipated to reach 12 knots. The engines were made by the Vulkan Company at Hamburg. Two other boats named the Hansdorf and the Hoisdorf have recently been completed by Howaldts Yard, using two partially-built hulls of "H." class destroyers, reconstructed as necessary. The overall dimensions of the resulting tankers are: Length, 71·8 m.; breadth, 9·1 m.; draught, 5·4 m.; registered tonnage, 980. These boats are each driven by one 410-h.p. heavy oil engine made by the Sulser Company, of Ludwigshafen.

It is now proposed to describe shortly the salient features of the various classes of torpedo boats built during the war.

Typical of the early "V." class is V. 67, built at the Vulkan Yard at Hamburg, and corresponds to the British "S." class. It will be seen from Table II that the legend displacement is 950 tons when carrying 150 tons of fuel. The armament included six 50-cm. torpedo tubes and three 10·5 cm. guns. The arrangement of the guns, tubes, &c., is shown on Fig. 2. Twenty-four mines were carried lashed to the deck and rails aft. No special dropping gear was provided for these mines. The arrangement of the torpedo tubes is common to this type of boat. Two single 50-cm. torpedo tubes were carried in embrasures, one on each side of the ship, just at the break of the forecastle.

To allow for these tubes being trained the break in the forecastle takes place well before the bridge. There were also two pairs of swivelling tubes, one pair just forward and the other pair just aft of the raised amidship gun, that is between the after funnel and the after mast. It will be noticed that the freeboard is low amidships, and these boats are said to have been very wet in a seaway. The propellers are direct-coupled to the shaft and run at 600 r.p.m. at full speed. There are three boiler rooms, one containing a single-ended oil-fired boiler and the other two each containing a double-ended oil-fired boiler. There are two engine rooms, each screw shaft being independent.

The next interesting type of destroyer is the "B. 97" class. As previously stated two of this type were being built by Blohm and Voss for Russia when the war broke out. They are larger than the "V." class, having a legend displacement of 1,350 tons when carrying 150 tons of oil fuel. The detailed dimensions are given in Table II. This class of destroyer corresponds to the British "V." class. In view of the fact that B. 97 was the first torpedo boat destroyer built by Blohm and Voss, the building time of 4¾ months is quite good. The arrangement of the guns and torpedo tubes is very similar to that described for V. 67, the only difference being that the midship guns are between the funnels. The general arrangement of guns, tubes, &c., is shown on profile drawing, Fig. 3. The horse-power of the main propelling machinery of this class of vessel represents a big increase on any contemporary German boat. The two propellers are directly coupled to the turbines and at 700 r.p.m. when developing 40,800 b.h.p. the speed obtained was just over 38 knots. As might be anticipated, this high power, coupled with the high number of revolutions led to considerable trouble with the propellers. There were four boiler rooms, each containing a double-ended oil-fired water-tube boiler, the two middle boiler-rooms being connected to the middle funnel. The maximum oil fuel stowage of 526 tons involved the filling of some anti-rolling tanks with oil as well as the ordinary storage tanks. The engines were arranged in two engine rooms, one abaft the other. Six vessels of this class were completed and the Germans spoke highly of this type of destroyer. When the war ended three more were being built by Blohm and Voss, viz., B. 122, 123 and 124.

Boats designated by the letter H. were built by Howaldts at Kiel, and only two, viz., H. 145 and 146, were completed by the end of the war. They were ordered in November, 1916, and not delivered till 1918; they are very similar to the V. 67 type of boats. The detailed dimensions of this type of destroyer are given in Table II. The six 50-cm. torpedo tubes are arranged as follows, one each side at the break of the forecastle as in V. 67, and two pairs of revolving tubes, one pair just abaft the after funnel and another pair just forward of the main mast. All guns are on the middle line. The general arrangement of this class of destroyer is shown on profile drawing, Fig. 4.

The most powerful and the most interesting type of German destroyer is the "V. 116" class, which have been referred to previously; the only boats completed were V. 116 and S. 113, but their trials had not been completely carried out before the war ended. The main dimensions were length, 110 m.; load displacement, 2,400 tons. The designed shaft horse-power was 48,000, and on trials 56,000 s.h.p. were developed, giving a maximum speed of 35 knots. The four 5·9-in. guns are all on the middle line and are provided with gun shields. Three of them are at the level of the forecastle, and the fourth is

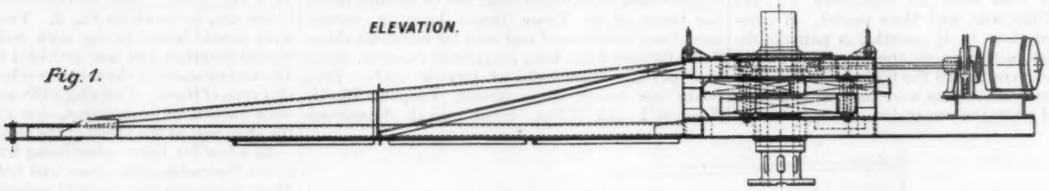
THE "CLYDE" SCREW-PILE DRIVING MACHINE.

CONSTRUCTED BY THE PATERSON HUGHES ENGINEERING COMPANY, LIMITED, GLASGOW.

(*For Description, see opposite Page.*)

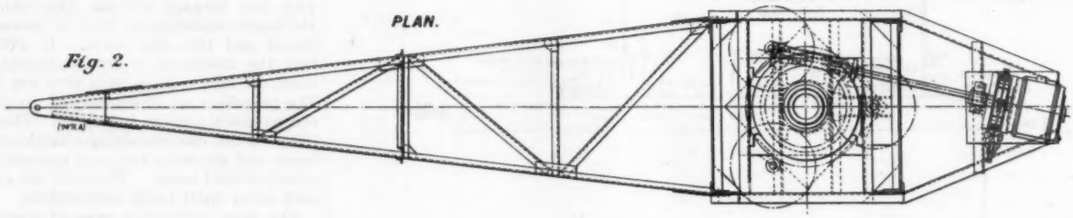
ELEVATION.

Fig. 1.



PLAN.

Fig. 2.



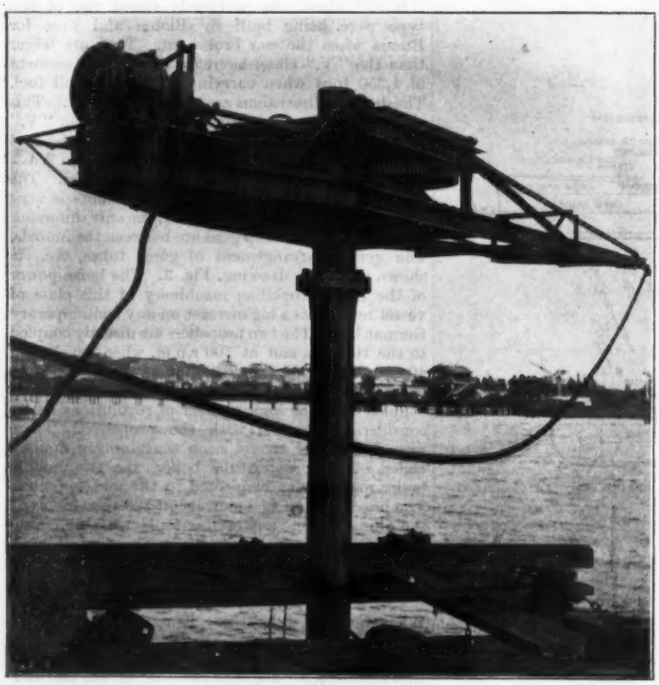


FIG. 3.

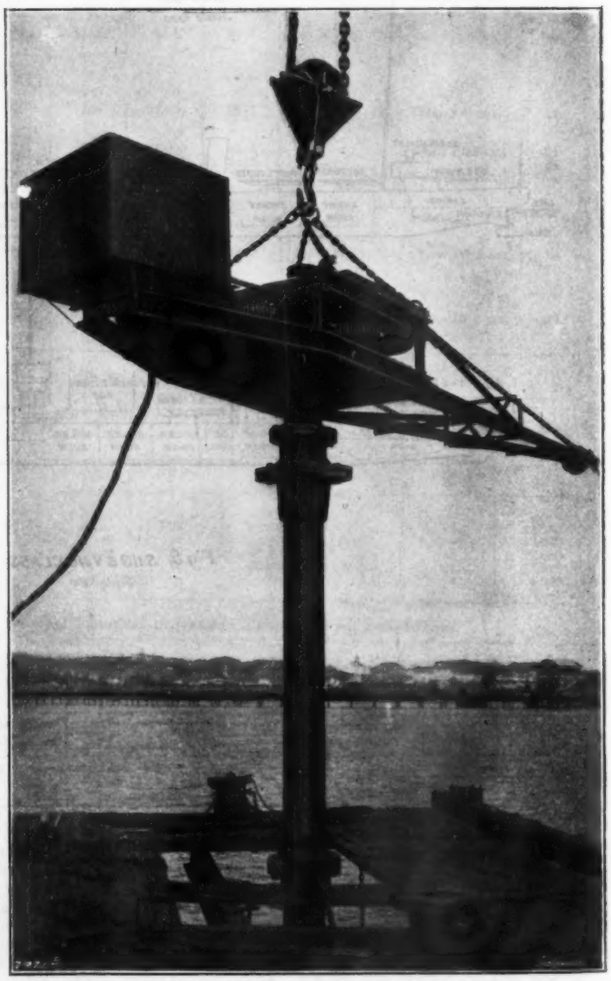


FIG. 4.

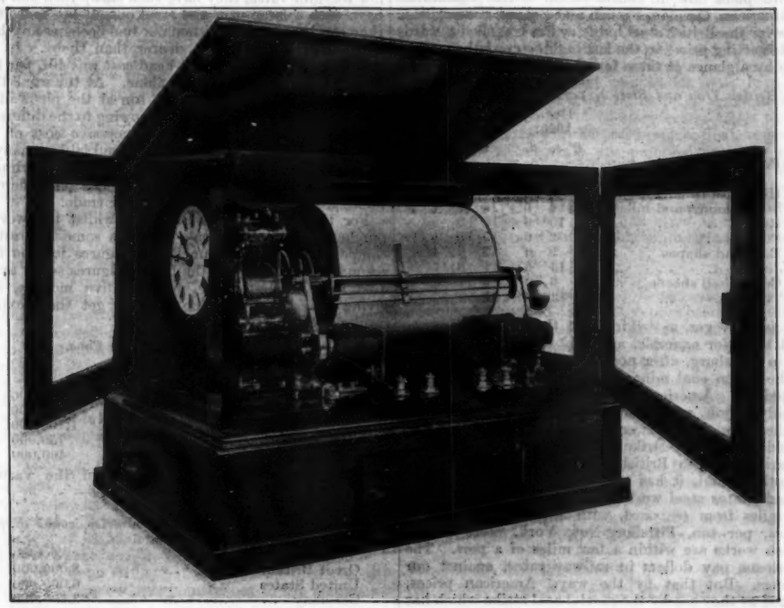
on the quarter deck aft. The arrangement of guns is very similar to that adopted in the flotilla leaders in the British Navy and is shown on arrangement drawing, Fig. 5. Director control is fitted to these guns and special arrangements are provided to ensure rapid loading. There were two pairs of swivelling deck torpedo tubes to take 60-cm. torpedoes, this being a unique armament for a destroyer. In addition to four torpedoes in the tubes, arrangements were made to carry spares. The four boiler rooms, each contained a double-ended water-tube boiler. The main machinery was accommodated in two engine rooms one abaft the other. The two propellers are direct-driven from the turbines without the interposition of reducing gear. The full oil fuel capacity was 600 tons.

This class of destroyer represents the highest type of offensive torpedo craft produced by Germany. It combined heavy gun and torpedo armament with a high speed. In scantling it approximates in some particulars to a light cruiser. Its *rôle* was to be attacks on convoys and also to engage Allied destroyers in the Channel. That the initial trials were satisfactory may be judged from the fact that quite a number of this type were building when the war ended. It might be of interest to compare the progress of ten years in German destroyers. This table shows the great advance made in marine engineering during this period whereby the weight per horse-power is reduced by 40 per cent., not allowing for the fact that the smaller weight refers to shaft horse-power against indicated horse-power for the earlier job.

It is only proposed to give a few particulars of the "A." class torpedo boats. The particulars of A. 26 to 49, in Table II, may be taken as typical of A. II boats. These vessels were built in batches and 30 of the "A. II" group were built by the Schichau Yards at Elbing and Dantzic. They were 50·1 m. long, and the armament included one 45-cm. torpedo tube in the bow and one 8·8-cm. gun at each end. This class of boat was built on the mass production system in 1915 and 1916 to get as quickly as possible the boats required for coast defence purposes. It would appear that the German ideas on torpedo craft changed radically as the war progressed. The duties originally

ELECTRIC TRAIN-RECORDER.

CONSTRUCTED BY MESSRS. GLENFIELD AND KENNEDY, LTD., ENGINEERS, KILMARNOCK.



allotted were mainly of a screening nature and, for torpedo attack with the Fleet. As the latter became less used the units were given greater offensive powers, so that they could be used as isolated vessels or in small groups unsupported by larger warships.

THE CLYDE SCREW-PILE DRIVING MACHINE.

THE usual method of driving screw piles by power, in which a spider is fitted over the pile and a rope wound round it, and then led off to a winch, requires a very considerable effort, and sets up large bending stresses in the pile being driven, as well as imposing considerable stresses on the temporary staging erected. In order to avoid these troubles in the old cumbersome method, a portable machine, which we illustrate in Figs. 1 to 4, on page 138, has been introduced. This is known as the Clyde Screw-Pile Driving Machine, and is constructed by the Paterson Hughes Engineering Company, Limited, 36, Charlotte-lane, Glasgow. The machine is simple, and its design and method of application will be so evident from the illustrations we give that they need only a brief supplementary description.

The machine consists of a frame built up of channels and angles, &c., mounted and balanced about a heavy steel shaft. The latter is fitted with a flanged coupling piece which bolts directly on to the top of the pile to be driven. The shaft is driven by motor through a worm and worm wheel and intermediate gears, the worm wheel being mounted on a sleeve, on which also a pinion is cut. The latter gears with three larger intermediate gears, which are integral with three small pinions which in turn mesh with a larger spur driving the shaft. The speed of the drive is thus geared down to suit the diameter of the pile, nature of the soil, and so on. Either a petrol motor or electric drive may be adopted, the machine illustrated being provided with the latter. The weight of the frame is taken on a large ball-bearing resting on a shoulder on the central shaft.

In use, the machine is slung by a crane over the pile, and the flange bolted to the top flange of the pile to be driven. A light cable is carried from the end of the long arm and made fast to a fixed point, on shore or part of the structure already built. Owing to the large radius of this arm, the actual load on this cable during the driving of the pile is comparatively light, and by adopting a light line which will carry away if the load becomes excessive, a very effective safety device is obtained to guard against damage or breakage of the pile, should an obstacle be met with while sinking. In addition to this, a safety device can easily be applied to the driving machine, if thought desirable. In addition to the elimination of heavy bending stresses on the pile, the use of this machine renders the erection of elaborate staging unnecessary. The staging employed need only be sufficient to carry guiding tackle to keep the pile in proper vertical alignment. We understand that in one contract recently, piles were sunk with this machine at from seven to ten times the rate previously attained in hand driving.

ELECTRIC TRAIN-RECORDER.

IN connection with the checking of train movements, Messrs. Glenfield and Kennedy, Limited, Kilmarnock, have recently devised and supplied to an Indian Railway two instruments of the type shown in the illustration above. The operation of these machines is simple, the record taking the form of a zig-zag curve drawn on the paper of the drum shown.

The drum is of gun-metal and revolves on horizontal bearings, being driven by a powerful spring clock, the mechanism of which can be seen to the left or near end of the case. The clock fitted can be either one to run for 24 hours or for 7 days at one winding. In front of the horizontal drum is a long screw geared to the clock, and this moves the pen slowly across the paper. The pen carrier is controlled by the electromagnets shown. By means of a suitable contact at a fixed point on the track, and a corresponding contact on the locomotive, each time an engine passes one or the other of these electromagnets is energised, according to the direction in which the engine is moving. On contact being made by the engine, current from the local battery energises one magnet and the armature is drawn over, the pen carriage being thereby pulled over in the same direction. If the train movement is in the opposite direction the other coils are energised and the pen is moved in the opposite direction.

The resulting diagram gives a continuous record of train movements at the point, the record being exact to within 30 seconds of the actual time of passing, while the nature of the curve at once shows the direction in which the train was going. The instrument can naturally be used to give indications at a distance, and the recorder can be safely housed in an office away from the track.

"ANUARIO DE MINERIA."—This year-book for 1922, the 22nd edition, gives information on the mines, metallurgical works, electric supply companies and other industrial concerns in Spain. It is issued by the well-known Madrid journal *Revista Minera, Metalúrgica y de Ingeniería*, at the price of 8.50 pesetas.

PROGRESS OF COAL LEASING ON PUBLIC LANDS IN THE UNITED STATES.—The United States Bureau of Mines, which has supervision of coal production operations on leased public lands of the United States, reports that up till May 31, there had been issued 180 coal prospecting permits, 5 coal-mining licenses, and 25 coal-mining leases. The total acreage involved amounted to 190,036. A total of 7,314 tons of coal had been reported by permittees, and a total of 586,538 tons of coal by lessees.

NOTES ON NEW BOOKS.

Whilst there is no royal road to mathematics, it is nevertheless true that the line of approach is often made unnecessarily difficult by purists who, ignoring the theorem of the philosopher, that in the ultimate every proof is intuitive, ban the approach to the calculus by geometric and physical intuition. Those who have to introduce the study to classes consisting of students whose need is a mathematical tool, rather than a system of philosophy, are little likely to maintain the foregoing viewpoint, should they ever have occupied it, and we can accordingly recommend, as well suited to engineers, the little book, entitled *Outlines of the Calculus*, which has just been published by Messrs. Mills and Boon, Limited, London, at 3*s.* 6*d.* net. The author is Mr. Terry Thomas, head of the military and engineering side of Haileybury College, and formerly Fellow of St. John's, Cambridge. The field covered is restricted to the simpler functions, but the reader who masters the volume will have obtained a very sound idea as to the nature and uses of the operations of differentiation and integration. There are numerous examples for practice, and a short table, in which the simpler standard integrals are collected, is printed at the end of the volume in a position handy for reference.

Books on the phenomena of plastic flow are sufficiently scarce to secure a welcome to the *Fluidity and Plasticity* of Dr. Eugene C. Bingham, a well-known worker in this field, Professor of Chemistry at Lafayette College, Easton, Pennsylvania (The McGraw-Hill Book Company, New York and London, 6 and 8, Bouverie-street, E.C.4, 20*s.* net). The book will be found instructive throughout, also from the historical point of view. In spite of its many formulæ, diagrams and tables, however, the book is written rather in the manner of an essay than that of a text book, and we cannot overlook the fact that the author promises a good deal that we fail to find. The preface says: "If we are to have a theory of flow in general, we must consider matter in three states. . . . . The author offers the theory given in the following pages with the utmost trepidation." No such theory has been given. There is no chapter on the states of aggregation at all, and we do not know why the author was in a state of trepidation. We are not in accord with his opening words: "Our knowledge of the flow of electrical energy long ago developed into the science of electricity, but our knowledge of the flow of matter has even yet not developed into a co-ordinate science." Is that justified? The theory of hydrodynamics may be complicated in that the flow of matter may be hydraulic (turbulent), viscous (linear) or plastic, as Professor Bingham says; but do we not profitably explain electric current, resistance, extra current, skin effect, &c., by hydraulic analogues? We are able to perform electric measurements with an accuracy not reached in hydrodynamics. Yet, when we come to fundamental conceptions, we are confronted by the same difficulties in both the branches of science. Dr. Bingham, to pass to another point, has placed nearly all his references in a separate index, alphabetically arranged as to authors, and serving also as name index. This index or bibliography—very comprehensive, certainly—occupies 82 out of a total of 440 pages; the full titles of the papers are given, often in their original languages. But the title does not always indicate the contents, and when the entry is, for example, Boussinesq, pages 6, 18, 50, followed by a long list of papers, we do not know which we should consult as to the law of Poisseuille discussed on page 50 of the book, though the date added to the name Boussinesq on that page facilitates the search in this case. Footnote references occupy an undue amount of space, and the reference problem is difficult, but Dr. Bingham's method cannot be said to be altogether satisfactory.

The Annual Reports of the Progress of Applied Chemistry, now before us in the sixth volume, dealing with the year 1921, have an established value. It may be owing to their increasing popularity that the Society of Chemical Industry, on whose behalf the volumes are compiled and published (through the Central House, 46 and 47, Finsbury square, E.C. 2; price 12*s.* 6*d.*) have been able to lower the price from 15*s.* last year. Economically, the reviews of the year given by the compilers of the sections could hardly be satisfactory, and technical advance has not been conspicuous. The year 1920 had been a lean one as regards large schemes requiring new chemical plants In 1921, again, we read more of minor improvements of existing plant and of work conducted with a view to arriving at a basis for improved design than of large installations. The joint action of the Association of British Chemical Manufacturers and the British Chemical Plant Manufacturers' Association in forming a committee for the standardisation of chemical plant is a step in the right direction, taken somewhat late

perhaps; but chemistry develops rapidly and there is little standardisation so far even as regards mining machinery. A very good beginning has been made with the report of this committee on the standardisation of filter presses; that report has brought out the importance of a small detail which, though by no means unknown, was little appreciated, viz., that there should be a flange on the side of the frame from which the washing liquid is discharged to prevent the liquid from passing round the edge of the cake without doing useful work. Increasing attention is being paid to improved methods of filtering, drying, evaporating, &c., but the adoption of laboratory methods must wait for the present. Fuel coal distillation and gas problems certainly received adequate consideration and discussion last year in connection with the Engineering and Gas Engineers' Conferences, the Board of Trade Committees, and other bodies; financial troubles were not overlooked on those occasions. In the dye and colouring-matters industries the impetus to research has been checked by the general overproduction, and research workers are not in too satisfactory a position. Paint and varnish manufacturers show little interest in research apart from the question of fine grinding; the leather industries have passed through one of their worst years; the textile and glass and ceramic industries have had their troubles, but their research associations are usefully active. The main interest of the reports lies in the details concerning novel investigations and devices.

Reinforced concrete has been the subject of many investigations in the last quarter of a century, its merits and limitations are well understood, and it is not to be expected that new text-books on this subject can diverge far from the older books in their general treatment. Each accession can only hope to infuse fresh interest by some novel treatment of details, for each one tells us that every endeavour has been made to develop the practical side of the subject and to present it in the simplest possible form. Mr. R. J. Harrington Hudson, of the Public Works Department (India), in his treatise on *Reinforced Concrete*: A Practical Handbook for Use in Design and Construction (Chapman and Hall, price 16s. net), has to submit to prevailing conditions. This work has an introduction by Mr. E. Fiander Etchells. As a somewhat late comer, Mr. Hudson covers ground that has been much surveyed, but in some sections he has done good if not original work. He divides his book into three parts, of which the first deals with materials, their preparation and character; the second is devoted to the design of beams, slabs and pillars, giving elaborate tables, whose use will shorten the work of the engineer. The third part, discussing secondary stresses in monolithic structure, appeals to us as the most interesting part of the work. The discussion here is limited to simple structures, and as the subject of monolithic structures is large, the author regards the present contribution as an introduction to further investigations. In connection with this subject, is given what is believed to be a new method of analysing the bending stresses in pillars. The method is apparently adequate, but the introduction of an unfamiliar "Standard notation" presents some difficulty to those long accustomed to a different form. This new notation requires an extensive glossary, which, inserted in its present position, interrupts the regular progress of the inquiry. Elaborate models of specifications and regulations are given, which add to the value of the work.

Trade with Greece.—The 1923 edition of the "Guide Commercial et Industriel Panhellenique Officiel," for which a circulation of 25,000 copies is claimed, is in course of preparation. The editor states that he will be glad to arrange for the insertion (free of charge) in this annual of the names of British firms having business with Greece, the Balkan countries and the Orient. Particulars should be sent to M. l'Ancien Inspecteur de la Commission Financière Internationale, Administration "Palais du Port," 2, Rue Salaminos, Salonica, Greece.

The Dortmund-Ems Canal.—According to the latest statistics published the Dortmund-Ems Canal, which indirectly joins the Rhine to the River Ems flowing to the North into the Dollart on the North Sea, has never been a financial success, and the expenditure in the year 1921 was six times the Canal revenue. The traffic, up and down the Canal, which means into and from Germany, has been fairly equally divided of late as to direction; before and during part of the war, the imports predominated decidedly. In 1913, the whole volume of traffic in both directions amounted to 4,269,000 tons (in round figures). During the war that figure went down to about 1,400,000 tons. Last year it had risen to a little above 2,000,000 tons. Whilst, however, the canal revenues in 1913, amounted to 696,000 marks and the expenditure to 1,157,000 marks, by 1919 the expenditure was 3,578,000 marks, against a revenue of 711,000 marks, and in 1920 and 1921, the revenues decreased (from 2,784,000 marks to 2,473,000 marks), but the expenses rose to 6,820,000 marks and finally to 14,473,000.

IRON AND STEEL COSTS AND COMPETITION.

The chief point in the problem of trade is the question of price, and a rough review of British and foreign iron and steel prices and competitive factors may not be out of place now, in consideration of the possibilities of American, German, French and Belgian competition. How far the British steel industry has travelled towards trade-getting prices in the last eighteen months may be seen by a glance at these few figures:—

British Iron and Steel Export Prices, per Ton.

	Dec., 1920.	June, 1922.
	£ s. d.	£ s. d.
Foundry and forge pig-iron	15 13 0	4 19 0
Hematite iron	14 0 6	5 0 2
Steel blooms and billets	37 4 6	10 19 7
Rails	24 10 6	10 2 9
Plates	47 2 6	13 15 4
Bars and shapes ...	37 9 0	13 6 4
Joists	28 14 6	11 5 7
Galvanised sheets ...	48 6 0	19 11 0
Tin plates	60 12 6	21 0 7

It is, however, a striking fact that to-day common steel bars, for example, are only 8*l.* 10*s.* per English ton in Pittsburg, after nearly four months of a strike at the union coal mines, whilst our British bars are quoted 10*l.* American prices have been advanced by, roughly, 6 dols. a ton since the beginning of the strike. If, therefore, those prices recede when the strike is settled to their pre-strike level, there will be a serious disparity between British and American prices. On the other hand, it has to be noted that, whilst the United States steel works are between 400 miles and 500 miles from seaboard, with a rail cost of nearly 8 dols. per ton, Pittsburg-New York, most of our British works are within a few miles of a port. The Americans pay dollars in railway rates, against our shillings. But that by the way. American prices, inflated as they are by the partial coal strike which has lasted since April 1, are still only as follows:—

United States Iron and Steel Inland Prices, per Ton.

	£ s. d.
Bessemer pig-iron	6 1 0
Foundry No. 2 iron	5 15 6
Southern No. 2	4 1 0
Billets and sheet bars	7 17 0
Rails (price not fixed)	9 10 0
Plates	8 11 0
Bars and shapes (about)	10 0 0
Joists and beams	8 11 0
Galvanised sheets	20 18 0
Tin plates	24 0 0

Some Belgian and French material is offered cheap, for delivery in this country, but too much importance need not be attached to this. When a really good international buying movement sets in, it will be found that no surplus France or Belgium can export will count for very much. Belgium, with her every furnace going, could only produce as much steel in twelve months as we could produce in six weeks. France, with the Lorraine thrown in, cannot produce or ship so much iron and steel as she did before the war without Lorraine, because she is so short of suitable labour and transport facilities for the heavy trades. Germany remains the chief European competitor, and she has lost one-third of her productive capacity. The United States is now the biggest rival we have to consider—and the most uncertain one.

We exported 5,000,000 tons of iron and steel in a year before the war. In the war period America managed to export 6,000,000 tons in a year. Possibly America could repeat that tonnage. But since 1914 we have had out steel works capacity so increased that, with our convenient shipping facilities, we could export 8,000,000 tons of iron and steel, and manufactures thereof, in a year. It is not likely that Germany, which exported more than 6,000,000 tons in a year before the war, could now export more than 3,500,000 tons. France, now that she has the Lorraine mines and works, might possibly at a stretch export 2,000,000 tons a year. It will be some time before little Belgium can reach 1,000,000 tons of exports in a year.

But to meet foreign competition, and to take, when a big buying movement develops, that share of export trade which our resources, facilities and needs entitle us to, we must have cheap fuel. This is the bottom question. Spread over the last three years of abnormal prices, the average pit-head cost of coal in the United States has only been 3 dols. a ton. This, indeed, is the quotation to-day for run-of-the-mine coal in Pennsylvania—before the strike is settled. British industrial coal is nearly twice that price. It is roughly true to say that we can successfully compete when our coal is 100 per cent. dearer than American coal, because we have our mines—ore and coal mines—iron works and shipping ports all very close together, whereas vast distances separate the ore from the fuel, and the works from seaboard, in America. Our average British haul for raw materials to works and for finished products to ports is under 30 miles. In the United States the ore has to be carried 1,000 miles to the coal, and the steel, if for export, must be carried nearly 500 miles to seaboard. Nevertheless, the Americans have such low ton-mile rates, they have such cheap fuel, and they have such a large iron and steel output per man, that they can beat us if and when our fuel becomes anything more than 100 per cent. dearer than theirs. In the first quarter of 1921 our pit-head cost was 40*s.* per ton, of which 30*s.* was for labour alone. At the same time American coal was only 12*s.* a ton at the pit-head, of which only 7*s.* 3*d.* was for labour, owing to the difference in output per man. It was the excessive cost of our coal that slumped our export trade and laid so many of our furnaces and ships idle. We are gradually winning back our trade, on low prices. We can only increase the cost of our coal at the cost of our trade.

For the limited trade available whilst the world's purchasing power is weak, there is some interesting competition. Taking our British figures for the first six months of the year, the foreign figures so far available for the first three, four or five months, and giving an estimate for the rest, we get these export results:—

Iron and Steel Exports, in Tons.
First Half of 1922.

From—	
Great Britain	1,625,000
United States	1,100,000
Germany	1,100,000
France	750,000
Belgium	400,000

The current exporting capacities of the various countries may be estimated as follows:—

Tonnages which the following Countries could Export Annually.

	Tons.
Great Britain	8,000,000
United States	6,000,000
Germany	3,500,000
France	2,000,000
Belgium	750,000
Total, including other producing and exporting countries ...	22,500,000

Against this potential exporting capacity, what is the potential demand? The exports of the exporting countries—and, therefore, the imports of the importing countries—aggregated about 18,000,000 tons a year before the war, the total world's consumption of steel being about 70,000,000 tons a year. For four years most of the steel produced went for war purposes. For another four years the world has failed to purchase, or consume, commercially, anything like its normal quantity of steel. In many lines we have something like eight years' arrears in railway and other constructions, in repairs and renewals, to make good. The world's accumulated steel shortage to-day, due to the war, is probably about 300,000,000 tons. In Continental Europe there are nearly 30 sovereign States, with 420,000,000 people. Only five of these countries can produce enough steel for their own needs. The United States, with less than 100,000,000 inhabitants, can consume nearly 30,000,000 tons of steel in a year—6 cwt. per head. If Europe could purchase only half as much steel, *per capita*, as America, the Continent would take over 30,000,000 tons a year. The aggregate producing capacity of the Continental countries is barely good enough for 20,000,000 tons a year. Africa and Asia have yet to be developed as considerable steel consumers. Nearly every country requires more railways and bridges, more tramways and other municipal facilities, mining machinery, agricultural implements and household utensils. There is a world of trade to conquer. Will we rise to the opportunity?

Metallising Large Surfaces by Cathode Rays.—As is well known, small mirrors such as are used for certain scientific instruments have in frequent instances been made by spluttering metal on them from the cathode of a vacuum tube. In a note recently presented to the Paris Académie de Sciences by MM. Lambert and Andant, a method is described by which large surfaces can be similarly treated. The main difficulty involved has been to maintain the required high vacuum necessary. The apparatus used by the authors of the paper consists of two large bell-jars, one inside the other. The joint between the outer jar and the plate of the machine is made by rubber, whilst the rim of the internal jar dips into an annular trough of mercury. A vacuum is maintained in both jars, but by compounding in the way described a much higher vacuum can be produced in the inner jar than in the outer, and with but a very minute difference in the levels of the mercury in the trough. An auxiliary air pump is used to create the vacuum in the first instance, which is then increased and maintained by a Gaede pump. The cathode consists of a disc of iron which is covered with a thin sheet of the metal to be deposited. It is stated that by this method it is possible to prepare mirrors large enough for use in such instruments as telescopes.

INDUSTRIAL NOTES.

Though the pooled vote of the Engineering Unions on the question of the withdrawal of the war bonus resulted in a large majority against acceptance, the executives concerned recommended their men to remain at work. No doubt the smallness of the vote had its influence on this decision, since of the 300,000 members of the Amalgamated Engineering Union less than 68,000 voted. It is not surprising that men should be reluctant to vote directly for a reduction in their wages, even although they may fully realise the inevitability of the cut. Probably many of the adverse votes should be considered merely in the light of a formal protest, those responsible for them having little hope that customers for engineering products could be compelled to make, at present rates, purchases adequate to maintain the industry. Another factor in preventing a stoppage of work was the ill-success that attended the recent attempt of the shop stewards to encroach on the functions of the employer, which resulted in the lock-out, with its consequent heavy losses. The largeness of the unemployed list, which is also advanced as a ground for the decision to avoid a stoppage, constitutes in itself evidence that labour costs must be reduced, and as the men refuse to allow this to be effected by a more rational employment of skilled men, the only alternative has been the cut, by which the existing war bonus is to be reduced in three instalments of 5*s.* 6*d.* each, of which the first takes effect as from July 31, the second on August 28 and the third on September 25.

The Federation of Shipbuilding and Engineering Unions has also balloted on the same question, and again the vote has been adverse to facing the facts of the situation. Whilst 16,064 were in favour of accepting the reduction, 32,069 opposed it, but again there is to be no stoppage, as is indicated in the following statement by Mr. John Hill: "It will be remembered that on the ballot paper it was pointed out to the members that unless there was a two-thirds majority against acceptance of the reductions there would be no stoppage of work, and, in accordance with this notification, the members will continue at work. The meeting has decided accordingly, and members are being notified that no stoppage is authorised. The unions reported very great difficulty in obtaining a full vote on this question owing to the inadequacy of the time allowed them for the ballot, and in the case of several unions, it was practically impossible for them to make a fair return."

Mr. Clynes has long been recognised as a labour leader much above the average in ability, and it is accordingly distressing to read the extraordinary statements which appear in a commentary to a pamphlet on the failure of Karl Marx, due to Mr. F. Thoresby. Mr. Clynes asserts that capitalism has been a failure for all but the few; a statement which is in flagrant contradiction with the actual facts, which show that during the past 150 years the condition of the "working man" has improved proportionately more than that of any other class in the community, and even more on the "moral and intellectual" side than materially; stupendous as the advance in this latter respect has been. A man is thought more of as a man than he was 150 years ago. That at the present moment unemployment is rife is certainly not due to capitalism, but mainly to the war against Prussianism and Zabernism into which we were forced, and of which much labour took advantage to profiteer with both hands. It has accordingly a responsibility for the existing distress only second to that of the Hun himself. If the capitalist had been unimpeded by labour in his efforts at reconstruction, employment would undoubtedly be far more general and the average "working man's" weekly takings considerably in excess of the present amount. Having made this protest against a grotesque perversion of the actual facts, we are glad to recognise that Mr. Clynes is less impracticable than many of his associates; and is disposed to help in trying to make the best of things as they are, rather than to destroy all existing conditions on the mere hope that the "intellectuals" of the labour party could effectually manage the businesses of the country. In spite of his preliminary charge against capitalism, he points out that from year to year workshops are made better, hours of labour reduced and much heavy and distasteful labour accomplished by machinery. Nevertheless he expresses a preference for the small capitalist as compared with the large one, although the official inspectors of factories insist strongly that it is the small capitalist that causes them the most trouble.

Mr. Clynes pleads for co-operation, but the value of this depends upon what is understood by the term. As ordinarily applied it has to be noted that the co-operative societies have not founded one single new industry, nor effected any material improvement in matters of distribution. For every advance made they have simply been parasitic on the thought of their capitalist competitors. There is, however, another form of co-operation such as was started at the South Metropolitan Gas Works by Sir George Livesey, which has at the least the promise of proving effective in reconciling capital and labour. Most interesting developments along the same lines have been made by Messrs. Lever Brothers, but it cannot be said that the plan has been enthusiastically welcomed by labour in its official capacity. All great creations of wealth are due to some individual who wields more or less autocratic powers, and could no more be replaced by a syndicate of directors of co-operative societies than a syndicate of literary critics could replace Shakespeare. It is difficult to reconcile this practical necessity for maintaining the initiative of the man of genius, with the theoretical demand that the workmen should secure a large share in the direct control of industry. If they do, the result is likely to be the same as in the co-operative societies, where nothing of importance is ever originated.

The average net selling price of bars and angles for the two months ended June 30 has been certified by the accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England to have been 11*l.* 8*s.* 0·27*d.* per ton, as against 11*l.* 5*s.* 10·24*d.* per ton for the previous two months, and under sliding scale arrangements puddling and other forge and mill wages on the North-East Coast will be advanced by 2½ per cent. for the months of August and September. Wages in the manufactured iron trade in Scotland will undergo a further reduction of 5 per cent. on the basis rates as the outcome of the examination of the employers' books for the months of May and June, the average net selling price brought out for that period being 11*l.* 6*s.* 6*d.* per ton.

The theory that the working man is entitled to a certain comfortable standard of living irrespective of whether he is able to earn it, found fresh exemplification at a meeting of the Sheffield Corporation tramway men last Sunday, which was held to consider the position that has arisen through the notice of the employers' side of the Joint Industrial Council to terminate the sliding scale agreement as to wages. A resolution was passed pledging support to the officials in resisting the "unjustifiable and unwarranted attack upon the standard of life of the tramway workers." At Poplar the corporation has to a large extent recognised the theory in question, and have decided that both their skilled and unskilled employees shall be paid wages in excess of the recognised rate. Only 50 per cent. of the agreed reductions on war bonuses are to be made, and the council has resolved that no unskilled workmen shall receive less than 80*s.* per week, their lower limit for skilled men being only 5*s.* more. It would matter less, were it not that other districts of the metropolis are rated to pay for Poplar extravagances. The rateable value there is admittedly low, but it is bound to be further diminished by the policy of the local authority.

Conditions in the coal trade are being discussed by the National Joint Coal Board. For the quarter ending December last the 55,000,000 tons of coal raised realised 57,000,000*l.*, but cost 56,366,000*l.* to win. The balance left works out at about 3¼*d.* per ton. At the Blackpool Conference the men demanded a voice in fixing the selling price, which, however, they have always had, at least indirectly. It is, however, one thing to fix a selling price and another to obtain it. Too high a price would still further reduce the demand and increase the number out of employment or working short time. Much of the present difficulty is due to the demand made by the Federation in 1919, that all men who were engaged during the war should be retained. In this connection it must be borne in mind, that many flocked to the coal mines during the war in order to avoid having to take their share in the dangers and hardships at the front. If these *embusqués* could be got rid of, the situation would be correspondingly eased. Some improvement is being effected by the American demand for coal, and Germany is also purchasing here, but the Welsh miners are characteristically threatening to stop work if more coal is sent to America.

The dispute in the printing trades is still unsettled, and very conflicting statements are made as to how matters are progressing. According to some accounts many men are returning to work on the terms decided at the Industrial Court, which were subsequently rejected by the Typographical Association. In this connection the Labour Minister has stated that reference to the Industrial Court or the alternative forms of arbitration provided under the Industrial Courts Act, 1919, could only be made by the joint consent of the parties, and if the purpose of the Act was not to be stultified the decision of the court must be final. Unless willingness to abide by the decision of the arbitration court is a prior assumption in all cases, arbitration is useless as a method of settling industrial disputes.

At a meeting on Monday the Typographical Association passed the following resolution: "Provided the employers refund the reductions already made, members may return to work at the old rates. Should the terms of a final national settlement provide for a reduction of wages, the amount of difference between the old rate and the rate payable at the time of settlement to be refunded to the employers, should such a condition be embodied in a settlement. The Typographical Association have received reports from their branches which clearly indicate that some statements in the press about men returning to work issued by the employers are incorrect. It is true that defections have occurred, but the great majority of our members remain loyal." The association refused, however, to be represented at a conference of the Printing and Kindred Trades Federation held in London on Monday, which resolved accordingly: "That this meeting of the Printing Trades Union regrets the refusal of the Typographical Association to attend this conference, called to consider questions of policy in which the Typographical Association was chiefly involved, and, in view of this refusal to discuss generally the serious position created by the dispute, the unions here represented are recommended to carry on their own work in their own departments."

At a conference held in York on the 27th ult., between the executive of the National Federated Electrical Association and the Electrical Trades Union, an agreement was arrived at by which each side recommends to its constituent body a reduction of wages of 5 per cent., to take effect on the second pay day in October, and a further 5 per cent. to come into effect on the second pay day in December. This agreement was later confirmed by a meeting of the National Joint Industrial Council. Agreement was only effected after protracted negotiation, great difficulty being experienced on both sides of the table in bringing the representatives of various districts into line.

Following the 16*s.* 6*d.* reduction in privately-owned shipyards, the Admiralty have decided on a similar reduction in wages of the Royal Dockyard workmen who have been receiving the 26*s.* 6*d.* bonus. As a result of a meeting of the Admiralty Shipbuilding Trade Joint Council it was announced that the reduction is to be made in four instalments: 7*s.* 6*d.* from July 16, 3*s.* from August 13, 2*s.* from August 27, and the remaining 4*s.* reduction is to be a matter of further negotiation, but in any case this will not be made before the end of October.

The recent award of the Industrial Court, presided over by Sir William Mackenzie, regarding railway shopmen is severely criticised by the district secretaries of the craft unions. The unions agree that they will have to co-operate with the National Union of Railwaymen in setting up machinery to carry out the award, but they have asked their executive first to meet Sir William Mackenzie to "clear up the flagrant anomalies." "The award," it is asserted, "regards the railway service as an industry in itself, a decision which we feel will be challenged vigorously." The wages and conditions part of the award is described as amazing, and the discrimination shown to certain railway centres as "passing all understanding." The gradings for classes of semi-skilled labour are stated to be "scandalous in the extreme." The most serious matter is said to be the deliberate ignoring of the agreements of individual unions.

The Secretary of the Ministry of Labour announces that the number of persons in Great Britain on July 24 recorded as wholly unemployed was 1,362,300. This was 6,974 fewer than in the preceding week, and 461,407 fewer than at the beginning of January. The number working short time and drawing benefit for intervals of unemployment was 72,900, as compared with 85,249 on July 17, and 934,786 on July 1, 1921.

Automobile Data.—The Institution of Automobile Engineers has recently issued a further series of data sheets relating to matters of interest in motor car work. The total number now issued is no less than 51, and they cover an immense variety of information of practical value in designing work. The early sheets relate to gear tooth proportions, sizes, &c., and provide formulæ for bevel and spur gears. Other sheets refer to engine constants, helical and laminated springs, power, gas velocity, air standard efficiency, conversion tables, threads (B.A. and B.S.F.), Newall limits, piston speed and acceleration, compression, the properties of aluminium sheets, and so on. It is the intention to issue other sheets to members from time to time, and if they maintain the standard of those just to hand, we do not doubt but that they will be found of very considerable value as the selection of data thus made will often save engineers a good deal of trouble in searching for what they want.

27-IN. UPRIGHT DRILLING MACHINE.

CONSTRUCTED BY MESSRS. A. A. JONES AND SHIPMAN, LIMITED, ENGINEERS, LEICESTER.

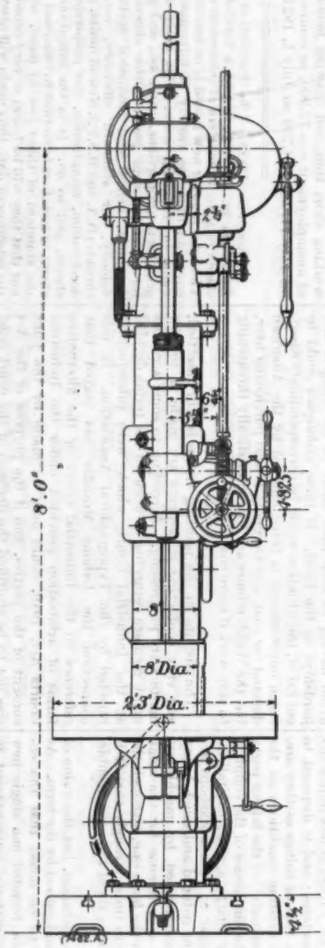


FIG. 1.

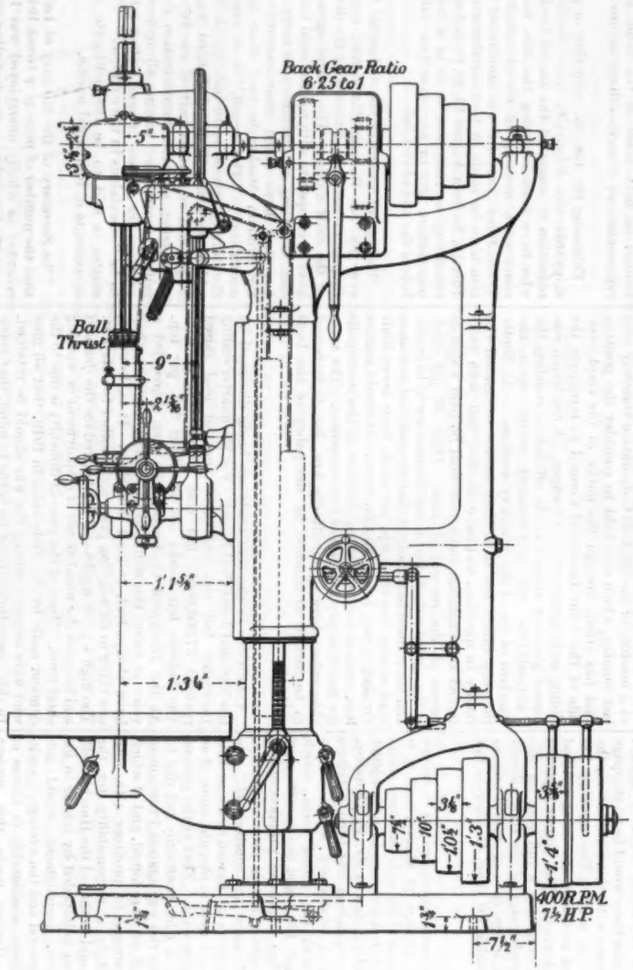


FIG. 2.

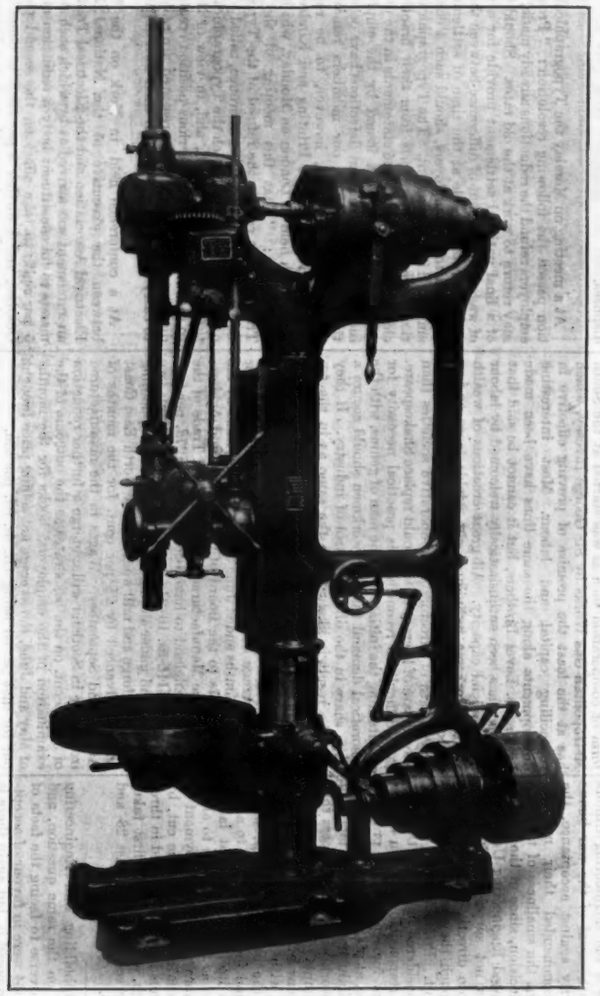


FIG. 3.

A NEW design of heavy duty drilling machine, by Messrs. A. A. Jones and Shipman, Limited, New Century Works, Leicester, is illustrated in Figs. 1 to 7, above and on page 143. The size actually illustrated in our drawings is a 27-in. machine. A 30-in. machine on similar lines is also built. The machine, as shown, is driven from a fast and loose pulley, 16 in. in diameter, and a four-step cone pulley which, with a speed of 400 r.p.m. for the main pulley, gives spindle speeds on direct drive of 100 r.p.m., 160 r.p.m., 250 r.p.m. and 400 r.p.m. With the reduction gear, housed in the casing close to the upper cone pulley, engaged, the spindle speeds are 16 r.p.m., 26 r.p.m., 40 r.p.m. and 64 r.p.m. The spindle has thus eight speeds, obtained by changing the belt on the cone pulleys and by moving the lever shown depending from the gear-box.

The feed spindle is driven through a small gear-box at the head of the column, the first-motion shaft of which is chain-driven from the main-spindle drive. The chain sprocket is best seen in Fig. 4. The gear-box gives six feeds, which are obtained by means of the two small levers shown on the box just below the index plate. These levers are fitted with dials giving the correct positions. The feeds are equivalent to 28, 40, 58, 80, 115 and 168 revolutions of the main spindle per 1-in. feed. Any of these may be thrown in while running. The vertical movement of the spindle in both sizes of machine is 13 in., the diameter

27-IN. UPRIGHT DRILLING MACHINE.

CONSTRUCTED BY MESSRS. A. A. JONES AND SHIPMAN, LTD., ENGINEERS, LEICESTER.

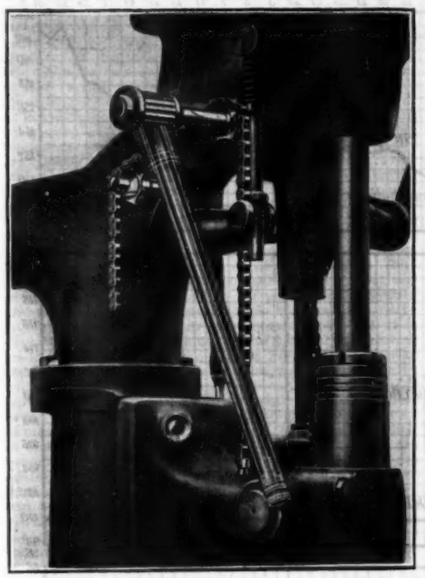


FIG. 4.

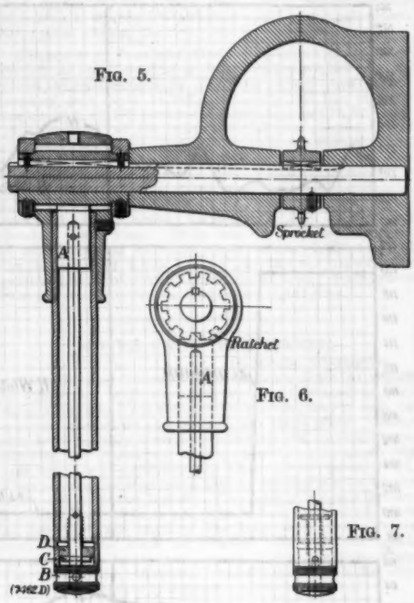


FIG. 5.

FIG. 6.

FIG. 7.

of the main spindle being 2 in. in the quill, the least diameter being 1⅞ in. The diameter of the quill is 3½ in. The sliding head has a vertical movement of 18 in. in the 27-in. machine and 24 in. in the 30-in. machine. To allow for this the drives for the spindle and feed spindle are by sliding key and keyway. Hand feed is by the large capstan handles. The cross-axle carrying the pinion-gearing with the quill rack is fitted with an outer bearing just inside the capstan handles, thus adding considerably to the stiffness of this part of the gear. This part incorporates a feed-trip lever, which instantaneously engages or throws out the automatic feed. An adjustable stop is clamped to the quill, and when this has been fed to the point set, the stop depresses a lever which disengages a dog clutch on the feed spindle. The sliding head is balanced by a weight inside the column, suspended by roller chain which passes over small sprockets. The head is raised or lowered by the reversible ratchet shown in Figs. 4 to 7, above. The illustration, Fig. 4, shows as exposed, parts which are properly enclosed within the column. Ratcheting in either direction is arranged for by rotating the pawl A inside the lever, by means of the cap B. A pin C, pulled into a slot in the fixed end D of the lever, by a small helical spring, serves to locate the pawl correctly. The operation is very quick and sensitive. The head may, of course, be locked in any position.

The table has a diameter of 24 in. and a vertical movement of 15½ in. in the smaller machine. In the larger, these dimensions are respectively 27 in. and 16½ in. The table is moved by a large crank handle and is provided with locks. The circular work-table can be revolved and clamped in any position. The belt shifter is operated by a handwheel with rack and lever, a single turn of the wheel shifting the belt from loose to fast pulley, and *vice versa*. The maximum distance from the nose of spindle to the table in the 27-in. machine is 34 in., and to the base, which is planed and fitted with tee-slots, 49 in.

The machine is intended to stand up to the heaviest work for its size, and will drill up to 3 in. The spindle is bored to No. 4 Morse taper. Tapping reverse is embodied in one pattern. If arranged for motor drive, a motor of 7½ h.p. is recommended to get full capacity out of the machine. The bearings, gears, &c., are all designed and finished to the firm's usual standard, the gun-metal bearings being ring self-oilers. Internal lubrication is provided to the top shaft and rack bush. The machine is well proportioned and would appear to be fully up to the high capacity the firm claims for it.

BRITISH ORDERS FOR AMERICAN STEEL.—It is stated that the United Steel Corporation have booked orders for railway material for India, South Africa, and Ceylon, and will re-start their works on the 14th inst.

LARGE PUMPING PLANT FOR THE SUDAN.

AT the present moment there is great activity in the Sudan in regard to irrigation work, the object being to increase operations in connection with the growing of cotton. The Sudan Plantations Syndicate have undertaken the irrigation of a considerable area of land, and for this purpose a very large pumping plant has recently been ordered. Negotiations for the supply of this pumping machinery were commenced during the early part of this year, and the contract was eventually placed with Messrs. W. H. Allen, Sons and Co., Limited, of Bedford. We think this is the first case of a very large work of this class in Egypt being carried out by a British firm. The machinery consists of three 950-b.h.p. Diesel engines driving three 45-in. pumps, complete with suction and discharge pipes, rising main, valves and auxiliary machinery. The Diesel engines are of the four-cylinder four-cycle single-acting trunk type, running at a speed of 150 r.p.m., with water-cooled cylinders and oil-cooled pistons. The engines are totally enclosed and are fitted with forced lubrication. The pumps are of the "Nile Conqueror" centrifugal twin series type, each pump has two casings connected in series by means of a pipe with two impellers on the shaft. The pump suctions are 45 in. in diameter. Each pump delivers 2 cub. m. of water per second against a maximum head of 25·5 m. when running at 150 r.p.m.

The pipework consists of three sets of 45-in. flanged steel suction pipes with straights, tees, bends and bell-mouths over a total distance for each set of 62 m. from the pump centre to the bell-mouth centre. There are also three sets of delivery pipes, 35 m. long, from the centre of the pump to the centre of the junction piece. The contract includes 650 m. of 72-in. rising main supplied in plates, which will be rolled and drilled ready for riveting together on the site. The auxiliary machinery consists of two 50-b.h.p. Allen semi-Diesel engines for driving dynamos, motor-driven circulating water pumps, charging pumps, compressors, &c. The whole of the machinery is to be delivered to the site and erected and running by June, 1923, and is being carried out by Messrs. W. H. Allen, Sons and Co., Limited, under the inspection of Mr. MacIntyre, of the Sudan Plantations Company.

EXPLOSION OF A TEE-PIECE ON BOARD A STEAMSHIP.

A PRELIMINARY inquiry has been conducted by the Board of Trade, under the provisions of the Boiler Explosions Acts, 1882 and 1890, with regard to the cause and circumstances of an explosion of a tee-piece, which occurred on December 7, 1921, on board the ss. Doriostar, when the vessel was lying in Prince's Dock, Glasgow. Unfortunately, one man, the fifth engineer, was killed.

The vessel was owned by the Blue Star Line (1920), Limited, Holland House, Bury-street, London, E.C.3.

The tee-piece in question was made by Messrs. Shaw and McInnes, Firhill Iron Works, Glasgow, in 1920, and was made of cast-iron and connected the auxiliary stop valve on the after centre boiler to the range of auxiliary pipes. It was of the following dimensions: bore, 6 in.; external diameter of body, 7½ in.; length, 15 in.; diameter of flanges, 12½ in.; thickness of flanges, 1 in., with eight holes in each flange, for ¾-in. bolts on a pitch circle diameter of 10 in. Since being fitted, no repairs had been required.

The vessel, including machinery and boilers, was inspected during construction by the surveyors to Lloyds' Register, with a view to classification. The owners' insurance was not effective at this time and the machinery and boilers were covered by policies taken out by the builders. This insurance was effected by the builders' agents in Glasgow, and distributed amongst several companies.

Mr. R. G. Shepherd, Engineer-Surveyor to the Board of Trade, in his report, states that the boilers and machinery of this vessel were installed by Messrs. G. and J. Kincaid, East Hamilton-street, Greenock, and the work was completed in July, 1921. There were six single-ended boilers arranged three abreast and back to back. These boilers were fitted with the usual mountings and adapted for firing either with coal or fuel oil. The auxiliary stop valves were of the non-return type, and the chests were fitted with ½-in. asbestos-packed drain-cocks. The main stop valves were 5 in. diameter and were direct-screw lift valves. The pipes in the auxiliary steam range were of solid drawn steel, $\frac{7}{16}$-in. thick, with flanges screwed on and caulked.

With regard to the erection of steam-pipe lines, Messrs. G. and J. Kincaid gave satisfactory assurance that the pipes in all steam ranges erected by them were in proper alignment and exact position before the joints were made. A particular method was adopted and it ensured a high degree of accuracy.

Steam was raised on six occasions between June 2, 1921, and November 30, 1921, and the official trials were run on July 19. No defects of any kind were observed in the steam pipes and connections during the trial. Previous to the trial, and during the period when steam was first raised, the tee-pieces attached to the auxiliary stop valves of the after port and starboard boilers were found to be defective. The defects occurred in the body of each casting at the junction of the branch connection, supplying steam to hydrokineters, with the main part of the casting. The defects were due to small blow holes in the castings at these parts. Replace tee-pieces were fitted and were found to be satisfactory. No other defects were observed by Messrs. Kincaid and Co., whilst the vessel was under their care.

Continuing his report, Mr. Shepherd stated that on the date of the explosion and shortly before the occurrence, the forward centre and starboard boilers were coal-fired, and the three after boilers were oil-fired. Steam was being supplied by the aft starboard boiler to the auxiliary range for all necessary purposes, the pressure being 160 lb. The forward centre and starboard and the aft centre and port boilers were all connected together, through their main stop valves, and the pressure common to them was 160 lb. per square inch. The fifth engineer received orders at this time to connect all five boilers by means of their auxiliary stop valves. It would be shortly before 5 a.m. when he proceeded to do this. Events appear to have happened very quickly. A brief interval is stated to have elapsed when the engine had to be stopped on account of water being carried over with the steam. At this moment the stop valves on the after port and centre, and the forward starboard boilers, were slightly open, and the fifth engineer was probably about to open the stop valve on the forward centre, or about to go there. He had only opened the valve one-eighth of a turn when the tee-piece exploded.

The tee-piece was fractured close to the forward flange, the line of failure being practically circumferential. The pipe forward of the tee-piece was displaced by the explosion a distance of 6 in. in the forward direction and 7 in. transversely to the starboard side. The appearance of the fracture was quite sound, the material being of a fairly close granular structure. The thickness of the casting at the fracture was fairly evenly maintained with a maximum of ⅝ in. full to a minimum of ½ in. full.

Mr. Shepherd, continuing his report, states that the actual order in which the valves and the drain cocks were opened cannot be stated, but from the arrangement of the boilers and the fact that the two after boiler valves were one turn open, and the forward starboard one turn open, it would appear that the order of opening would be after port, centre, forward starboard and centre. Thus the valve and drain on the after centre boiler would be open for the space of time taken by the fifth engineer to go to the forward starboard valve, open it, and from thence to the forward centre valve. The water lying in the centre line of pipes would be draining out during this interval, and when the drain on the forward centre boiler was opened, the drainage would be accelerated. This would be sufficiently rapid to bring the cold water of condensation lying in the pipes into contact with steam, thus commencing the action of water hammer. The disposition of the pipes after the explosion indicated that the direction of the rush of water which caused the rupture was along the length of the pipe from aft to forward. The presence of water in the pipes was sufficiently accounted for by the fact that the system was under steam for some days previously, and that at this part there was in effect what might be termed a dead-end.

When the knocking occurred in the engine, it is probable that water was being carried over from the port line of pipes. To support this view, the pressure gradient in the auxiliary pipes would be a maximum at the aft starboard stop valve and lowest at the most remote point in the engine room where steam was being used. Thus, at the tee-piece through which the steam from all boilers was led to the engine-room range, the pressure would be lower than at the auxiliary stop valves. There would be little tendency for the steam from the centre aft and forward starboard boilers to travel in that direction, as the pressure would be the same from these boilers to the after starboard boiler.

Thus, with a somewhat lower pressure at the engine-room tee-piece than at the aft port stop valve, the steam would flow from there and carry with it water of condensation, this giving rise to knocking in the engine of the dynamo.

Mr. Shepherd, concluding his report, stated the explosion was due to water-hammer action brought about by opening draincocks attached to a range of pipes which were under steam and partly full of water.

Mr. Thomas Carlton, Engineer-Surveyor-in-Chief to the Board of Trade, in his observations, states: "The case dealt with is one of many illustrating the grave danger of clearing steam-pipe ranges of water whilst they are in open communication with boilers under steam pressure. If a pipe range is found to contain water of condensation, the drain cocks should not be opened, or, if obstructed, cleared of obstruction until the boiler stop-valves have been shut. The latter should then be opened very slightly, just sufficient to blow the water out of the range, but not sufficient for the steam to escape in dangerous quantities in the event of a shock of water hammer and fracture of a pipe occurring. The danger to life is not the shock of the water-hammer, but the rush of steam in great volume from the boilers through the pipe or valve which has been fractured by the shock. In a closed compartment, such as a boiler-room on board ship, access to the boiler stop valves cannot be obtained until the steam in the boilers has wholly escaped, and even if, as in some few instances, the valves can be closed from the deck above, the escape of steam in a few seconds is quite sufficient if the valves are fairly wide open, to injure fatally anyone who cannot instantly escape from the compartment, hence the importance of first closing the stop-valves and then opening them the smallest amount possible to permit of a gentle clearing of the pipes of water and heating of the range. When the range is clear of water and heated up, the stop valves may be opened with safety."

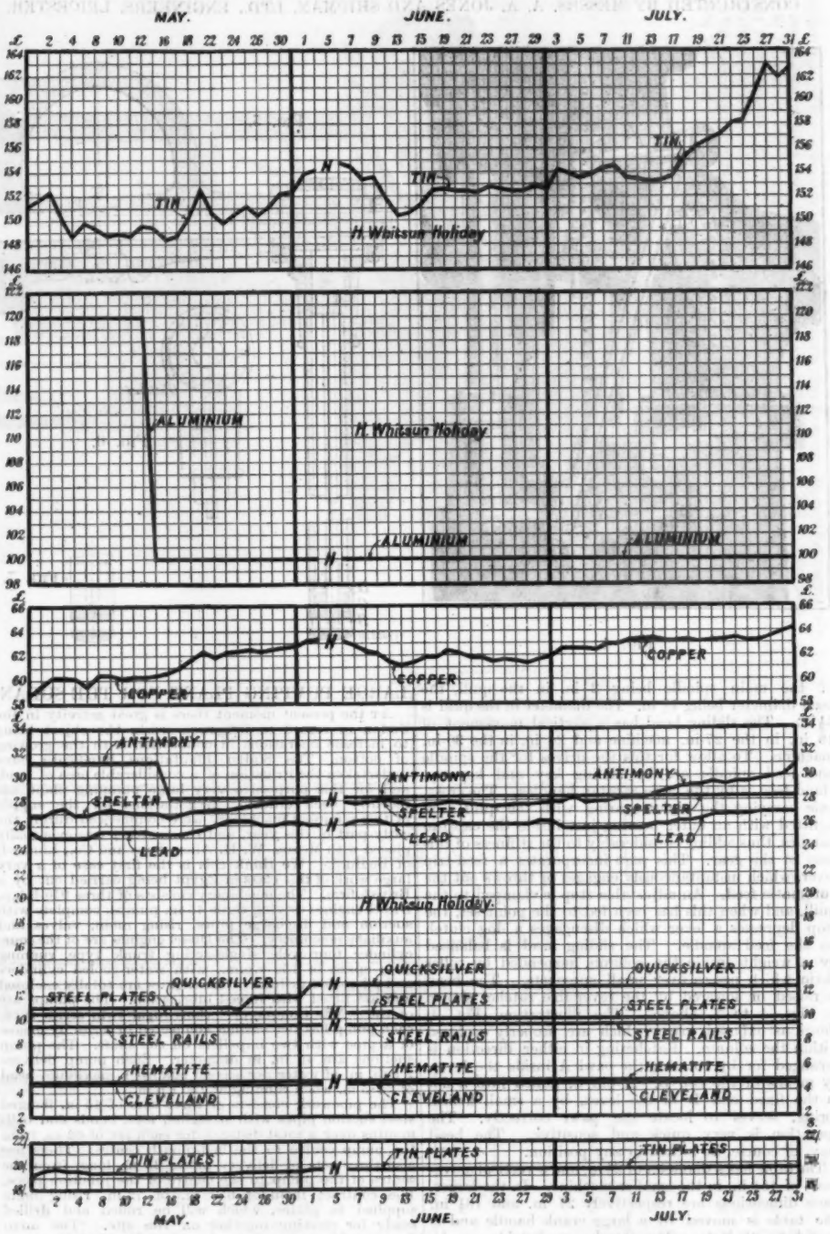
The late Dr. Alexander Graham Bell.—The death of Dr. Graham Bell, the famous inventor of the telephone, took place at Baddeck, Nova Scotia, on the 2nd inst. Dr. Bell was born in Edinburgh in 1847, and was thus in his 76th year. The invention on which his fame rests was perfected in its original form in 1876, and was the outcome of attempts to construct an electrical apparatus which would enable the deaf to hear. Dr. Bell was a man of considerable scientific attainments, and had other important inventions to his credit in addition to the telephone. He also did original early work in connection with aeronautics. We will hope to deal fully with his work and career in our next issue.

Cradock's Wire Ropes.—Messrs. George Cradock and Co., Limited, of Wakefield, have recently issued a new edition of their large catalogue of wire ropes which contains extremely complete information, both as to the very large variety of wire ropes made by the firm and as to the multifarious uses to which these ropes are applied. Ropes varying from the finest aeroplane tie wires to locked coil winding ropes having a breaking stress of over 300 tons are listed under their various classifications, in every case with full data as to their construction and characteristics. As Messrs. Cradock and Co. not only manufacture the wire from which their ropes are made, but also make their own steel for the purpose, they are in a position to duplicate any rope which has proved exceptionally satisfactory, and they can take the fullest responsibility for everything turned out of their works. The catalogue contains an illustrated description of these works, reprinted from Engineering, and also gives information regarding aerial ropeways, cableways, suspension bridges, &c., manufactured and supplied by the firm. Instruction is given as to the proper care of ropes and full explanations are presented as to splicing, capelling, fixing sockets, &c. The convenience of buyers abroad is still further studied by the complete coding of the catalogue.

Standard Specification for Girder Bridges.—The British Engineering Standards Association has just issued as one publication Parts I and II of the British Standard Specification for Railway and Highway Girder Bridges (Report No. 153—1922). The preparation of a British Standard Specification was undertaken by the association primarily at the request of its China Local Committee, which had pointed out the advantage to British trade of a specification similar to those existing in other countries, the object in view being to provide designers and manufacturers with definite lines upon which to work so as to obtain a uniform result as far as strength and utility are concerned, whilst leaving the question of type open to the unfettered discretion of the engineer. The principal structural steel firms in this country also approached the association with a view to a British standard specification for workmanship in the construction of girder bridges being drawn up. The present document embodies the published results of the work as far as it has proceeded; other portions of the specification will be issued from time to time as completed. Part I of the report covers the materials to be employed, which are required to be in accordance with one or other of the existing British standard specifications. These latter are included as appendices, making the present document complete in itself. Part II of the report deals with workmanship including, amongst the various items, straightening, planing and shearing, drilling, punching and reaming, rivets and riveting, bolts and nuts, temporary erection at contractor's works, painting, measurement and packing and marking for export and so on. Copies of the report, price 1s. 2d. post free, may be obtained from the Secretary of the Association, 28, Victoria-street, Westminster, S.W. 1, or from Messrs. Crosby, Lockwood and Son, 7, Stationers' Hall-court, E.C. 4.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

The Sequestrated German Patents in America.—President Harding has ordered the Alien Property Custodian to demand the return of the sequestrated German patents that were sold to the Chemical Foundation, Inc. The demand, which affects 4,000 patents and other property, is said to be based on the ground that the German patents were sold at prices insufficient to protect the interests of the former German owners for whom the Alien Property Custodian acts as trustee. The patents were sold in 1919 to the Chemical Foundation for 250,000 dols., but their value is problematical, as the policy of the Foundation has been to issue non-exclusive licences for working them; and it is also said that less than 2 per cent. of them had been found of use. Mr. Francis P. Garvan, president of the Foundation, stated in an interview that the action was taken without giving any notice to the United States organic-chemical industry or to the Chemical Foundation, and was begun, so he was informed, after the representatives of the German "Interessengemeinschaft" and the German Government, but not American interests, had been heard by the United States Attorney-General. It is stated that the demand will be refused and the issue decided in the District of Columbia Court.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Though improvement is by no means as rapid as could be desired, consistent headway towards a better state of things is being made throughout all branches of the steel and engineering industry. Perhaps the one exception is shipbuilding. In this department there is a certain amount of work on hand for plates, castings, fittings and tools, but expiring contracts are being renewed with extreme sluggishness, and there appears to be little prospect of inducing potential customers to release requirements until prices undergo a still further revision. Otherwise, an abundance of inquiries for steel and steel products is materialising in a larger percentage of solid orders. Home railway companies still display extreme caution in inviting tenders for renewals, but on Colonial account purchasers are coming more freely into the market for axles, tyres and springs, and several departments which were largely idle three months ago are now working to one-third of their normal capacity. Steel makers on the outskirts of Sheffield have benefited substantially from the revival in the overseas demand for lower quality products. The six furnaces just recently recommissioned are disposing promptly of the whole of their output. The low level of current prices is attracting buyers, especially as German values are on the up grade and deliveries uncertain. So far high-grade steels have not shared to any appreciable extent in the improvement, but it is expected that as conditions in the general engineering trade become more robust, and as immense war stocks are absorbed, this specialised branch of Sheffield industry will again come into prominence. Steady improvement is reported in electrical engineering, while arrears of orders in the textile branch are sufficient to guarantee activity in many cases for two years ahead. Files are beginning to share in the more prosperous conditions which are becoming manifest in the lighter section. Twist drills are again freely on order for shipment, and there is a more marked movement in joiners' tools, mining machinery and appliances, machine tools, and saws. Despite the booking of several useful orders during the past fortnight, the agricultural machinery branch is still in a depressed condition, but as stocks of farming requisites are exceptionally light, and as renewals are long overdue, the outlook is viewed with a measure of hope. In view of the increased activity at steel furnaces, scrap holders are demanding higher rates, and as stocks have been considerably depleted by recent exports to the Continent, forward contracts are generally in favour of merchants.

South Yorkshire Coal Trade.—The general position continues firm, with little appreciable change in any section. A slow but consistent improvement is exhibited in house coal, though buyers both in London and locally are operating cautiously pending a definite move in prices. Railway companies are steadily repleting stocks under renewed contracts. The increased activity at steel furnaces is reflected in the improved demand for industrial fuel. Shipments are distinctly more active. Slacks are scarce. There is a minor improvement in foundry and furnace coke. Quotations:—Best branch handpicked, 36*s.* to 37*s.*; Barnsley best Silkstone, 33*s.* to 34*s.* Derbyshire best brights, 27*s.* to 28*s.* 6*d.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 22*s.*; Derbyshire best small nuts, 16*s.* to 16*s.* 6*d.*; Yorkshire hards, 23*s.* to 24*s.* Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Little new is ascertainable just now concerning Cleveland pig-iron. Most descriptions are plentiful, and weakish in price, notable exceptions, however, being No. 1 and siliceous sort. Fairly good American demand is reported, and the inquiries are for ordinary foundry iron, as well as for ferro-manganese and other special kinds usually sold to America. Movement in the freight market, however, is for the time being checking actual business with the States. Home needs are very moderate, and inquiry on Continental account keeps extremely quiet. No. 1 and siliceous iron continue firm at 95*s.*; No. 3 G.M.B. is 88*s.*; No. 4 foundry, 87*s.*; No. 4 forge, 85*s.*; and mottled and white are 80*s.* all f.o.t. makers' works, or f.o.b. Tees.

Hematite.—At length there is a free market for East Coast hematite, makers no longer adopting the course of agreeing to a minimum figure. With prices once more a matter of individual bargaining, business has been put through on lower terms than those last quoted. Supply is abundant, and the already large stocks are increasing so that makers are anxious to sell. Mixed Nos. are on offer at 91*s.* for export, and at 1*s.* to 1*s.* 6*d.* above that figure for home purposes.

Ironworkers' Wages.—According to the accountant to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England, the average net selling price of bars and angles for the two months ending June 30 last, was 11*l.* 8*s.* 0·27*d.* per ton, as against 11*l.* 5*s.* 10·24*d.* per ton for the previous two months, and under sliding scale arrangements, puddling and other forge and mill wages on the North-East Coast are advanced by 2½ per cent. for the months of August and September.

Manufactured Iron and Steel.—Values of manufactured iron and steel tend downward. In one or two branches a fair number of inquiries are circulating, and one or two contracts have recently been secured, but generally the situation continues very unsatisfactory, with a vast amount of plant still lying idle. Keen competition for overseas trade enables customers to place export orders at very substantially below the following rates, which are the recognised market quotations for home business:—Common iron bars, 12*l.*; iron rivets, 12*l.* 17*s.* 6*d.*; soft steel billets, 7*l.* 15*s.*; medium steel billets, 8*l.* 5*s.*; hard steel billets, 8*l.* 15*s.*; steel ship, bridge and tank plates, 10*l.*; steel boiler plates, 13*l.* 10*s.*; steel angles, 9*l.* 10*s.*; steel joists, 10*l.*; heavy sections of steel rails, 9*l.* 10*s.*; black sheets, 12*l.*; and galvanised corrugated sheets, 16*l.*

Shipments of Iron and Steel.—Shipments of iron and steel from the Tees during July totalled 67,733 tons, of which 35,462 tons were pig-iron, 3,681 tons manufactured iron, and 31,282 tons steel. Of the pig-iron despatched, 11,113 tons went coastwise, and 21,657 tons went abroad; of the manufactured iron cleared, 1,439 tons went coastwise, and 2,242 tons went abroad; and of the steel cleared, 5,276 tons went coastwise, and 26,006 tons went abroad. The largest customers for pig-iron were: Wales, 8,093 tons; the United States, 5,825 tons; Italy, 4,470 tons; Belgium, 3,730 tons; Scotland, 2,620 tons; Germany, 2,353 tons; and Sweden, 1,830 tons. India was the heaviest importer of manufactured iron and steel, taking 1,621 tons of the former, and 6,935 tons of the latter. Other large receivers of steel were, Nigeria, 3,537 tons; Portuguese East Africa, 2,210 tons; and Japan, 2,081 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There is little fresh to report in connection with the steel trade of Scotland as conditions have not yet returned to normal, and it may be a little time before any opening out takes place. Bookings have recently been unsatisfactory and consumers are showing no disposition to buy, preferring to go slowly and have few commitments when prices come down. They seem quite convinced that by waiting a little longer they will reap the benefit. Inquiries are again better, but too many of them are only feelers. The works now in operation are nothing like fully employed. Prices over the week show no change. Most of the black sheet makers have again resumed and conditions are the turn better. Export is chiefly responsible for this as the home market is still very quiet.

Malleable Iron Trade.—The malleable iron trade of the West of Scotland cannot be described as in a very flourishing condition at the present time. During the stoppage there were not many fresh orders placed, and the immediate outlook at most of the works is not very bright, but some improvement is bound to come along in the near future. Inquiries now in the market would tend to show that there are prospects of more business being booked as soon as general trade picks up a bit. Prices are unchanged with "crown" bars called 10*l.* 10*s.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—The tone in the Scottish pig-iron trade continues good, but the translation of inquiries into actual business is just a trifle slow. Bookings are, nevertheless, a shade better, and foundry iron is in more request. On the other hand, the demand for hematite is decidedly poor still and little improvement is looked for until a healthier state prevails at the shipyards and steel works. The following may be taken as the current quotations: Foundry iron, No. 1, 4*l.* 17*s.* 6*d.* per ton, and No. 3, 4*l.* 12*s.* 6*d.* per ton, at makers' yards; and hematite, 5*l.* 8*s.* 9*d.* per ton, delivered at the steel works.

Wages in the Iron Trade Reduced.—The following intimation has been made by Mr. John M. MacLeod, C.A., to the joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board: "In terms of the remit I have examined the employers' books for May and June, 1922, and I certify the average net selling price as 11*l.* 6*s.* 6*d.* per ton." This means a decrease in the wages of the workmen of 5 per cent. on basis rates.

Scottish Shipbuilding.—The shipbuilding returns for the past month of 13 vessels of 40,211 tons, are equal to about the average for the seven months of the year, and have made little difference in the decreased output as compared with last year. For the year to date the figures are 88 vessels of 220,484 tons, which is nearly 93,000 tons worse than for the corresponding period of last year. The totals for the past month and for the year to date are as under:—

	July, 1922.		Jan.–July, 1922.	
	Vessels.	Tons.	Vessels.	Tons.
The Clyde	11	32,961	73	200,454
The Forth ...	1	250	4	10,023
The Tay	1	7,000	4	9,900
The Dee and Moray Firth	—	—	7	137
Totals	13	40,211	88	220,484

The principal vessel launched on the Clyde during the past month was the twin-screw geared turbine Volendam, 15,150 tons, which was built by Messrs. Harland and Wolff, Limited, Glasgow, for the Holland-America Line, Rotterdam, and had it not been for that vessel the Clyde output for the month would have been the lowest for July for many years back. The total for the year to date is nearly 65,000 tons behind last year, 150,000 tons behind 1920, and 176,000 tons behind the record year 1913, while it is thirteen years since there was a lower output for the corresponding seven months. Conditions at the various yards are very poor and almost no new contracts have been fixed up recently.

NOTICE OF MEETING.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, August 5, at 2 p.m., in the Lecture Theatre of the Institute, Newcastle-upon-Tyne. Annual General Meeting. Annual Reports of the Council and Finance Committee will be read. Election of office-bearers and council for the ensuing year. Election of representatives on the Council of the Institution of Mining Engineers.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The June coal audit for South Wales shows the worst result since the national agreement reached twelve months ago. For the first time the proceeds were insufficient to cover standard costs. The proceeds in June according to the certificate of the joint accountants amounted to 3,136,433*l.*, and costs to 3,243,027*l.*, made up of 1,999,694*l.* for standard wages plus 20 per cent. minimum, and other costs 1,243,333*l.* There was thus a loss of 106,594*l.* In addition the owners have to surrender their standard profits, 283,272*l.*, making a total loss of 389,866*l.* They are, however, entitled to carry forward the actual deficit of 56,480*l.*, making the irrecoverable loss in June 333,386*l.* Since November last the owners have been compelled to sacrifice 1,984,000*l.* During that period the proceeds of the industry have amounted to 28,477,102*l.*, of which amount wages have absorbed 17,128,062*l.*, or 60 per cent., other costs 10,982,848*l.*, or 39 per cent., and the owners 366,192*l.*, or 1 per cent. If the proceeds of the industry during the eight months had been sufficient to justify the payment of the minimum wages of 28 per cent. above the 1915 standard, the profits retainable by the owners would have been 2,935,192*l.*, instead of which they have retained only 366,192*l.* The chief causes of the unsatisfactory results in June were a reduction in the output of coal as well as in the quantity sold, and a fall in the average selling prices. The output in June was about 929,000 tons less than in May, attributable to the Whitsuntide holidays and partly to the depression in trade. On the other hand, the cost of production was increased by 1*s.* 8*d.* per ton, of which labour costs were increased by 6*d.* and other costs by 1*s.* 2*d.* There was also a decrease in selling prices of about 6*d.* per ton. In the light of these returns the miners' wages this month will remain on the minimum. Fortunately, there is a prospect of an improvement this month as a result of the placing of large orders for Welsh coal by America. The miners will not, however, reap any benefit, except in regularity of employment, until October, for July was a poor month and the September wages will be regulated by the July results, and those for October by the August results. At present business on the coal market has been rendered extremely difficult by the fact that most collieries are fully booked up for this month, and in many cases over September also. Already steamers representing a carrying capacity of 625,000 tons have been chartered to carry Welsh coal to the United States and Canada and 40 of 130,000 tons have actually been "entered outwards" by the Customs. At the docks shipping operations are on an active scale, and instead of tips standing idle from lack of trade vessels are now waiting for loading berths. Busy times are assured for the next month at least even should America not place an order for another ton of coal.

Iron and Steel.—The inquiry for Welsh tin plates has slightly improved and prices are steady at 19*s.* 3*d.* to 19*s.* 4½*d.* for standard boxes. Exports of iron and steel goods in the past week totalled 7,387 tons, compared with 16,811 tons in the previous week. Shipments of black plates amounted to 1,371 tons, tin plates to 5,183 tons, galvanised sheets to 666 tons, and iron and steel to 147 tons.

TIN SUPPLIES.—The shipments of tin from the Straits to the United Kingdom during July totalled 660 tons, as compared with 2,880 tons in June and 1,280 tons in July of last year. Shipments to the United States do not show the same variation, the corresponding figures being 2,885 tons, 3,450 tons and 2,500 tons. During the month 2,414 tons were delivered to the United Kingdom and 4,590 tons to the United States.

A MACHINE FOR ROAD-SURFACING.—In a paper to the Institution of Municipal and County Engineers, Mr. A. Dryland, county engineer for Middlesex, drew attention to the need for some machine for trimming off road surfaces to the required contour. There were, he said, many roads, which, whilst quite sound, were uneven, but with present equipments they could not be satisfactorily surfaced without breaking up and re-consolidation. If a machine could be devised which could be adjusted to pick off all convexities so as to leave an even surface it would, he said, be a money saver.

BOMB DROPPING TRIALS AGAINST WARSHIPS.—The Royal Air Force and the Royal Navy have been co-operating in bomb-dropping trials carried out by aeroplanes against wireless-controlled ships. The ships used have been the obsolete Agamemnon and the destroyer Opportune. The bombs used are of a new practice pattern, which weigh 9 lb., and burst into smoke on striking an object. The heights from which they have been dropped varied up to 8,000 ft. Trials of this nature are intended to form part of the annual training programme, and will be valuable in testing new bomb-dropping appliances, &c.

METHODS OF STOWING SHIPS' LIFEBOATS.

(*For Description, see Page* 156.)

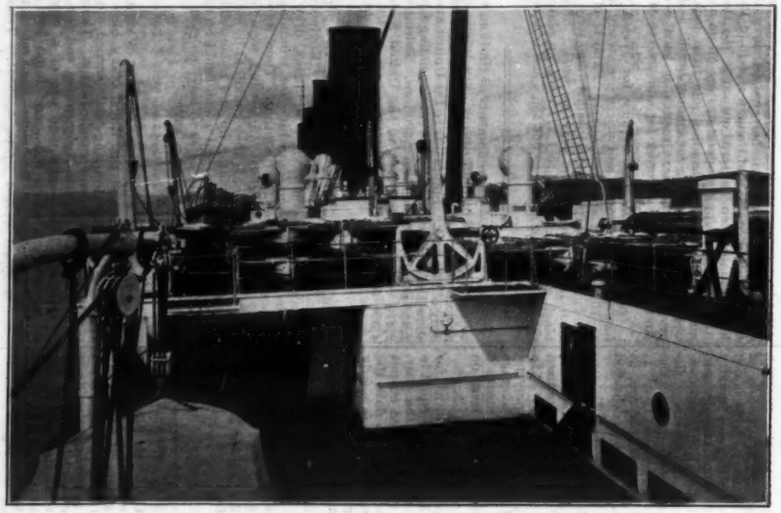


Fig. 1. Arrangement of Boats on the SS. "Aquitania."

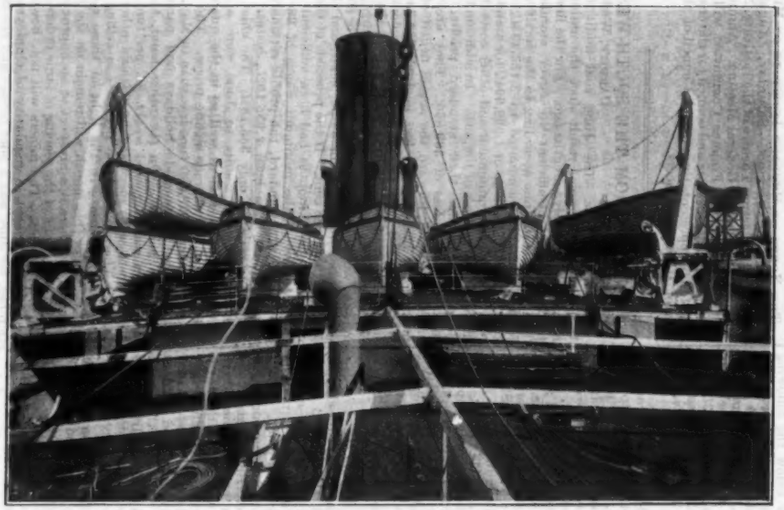


Fig. 2. Inefficient Inboard Nesting Arrangement.

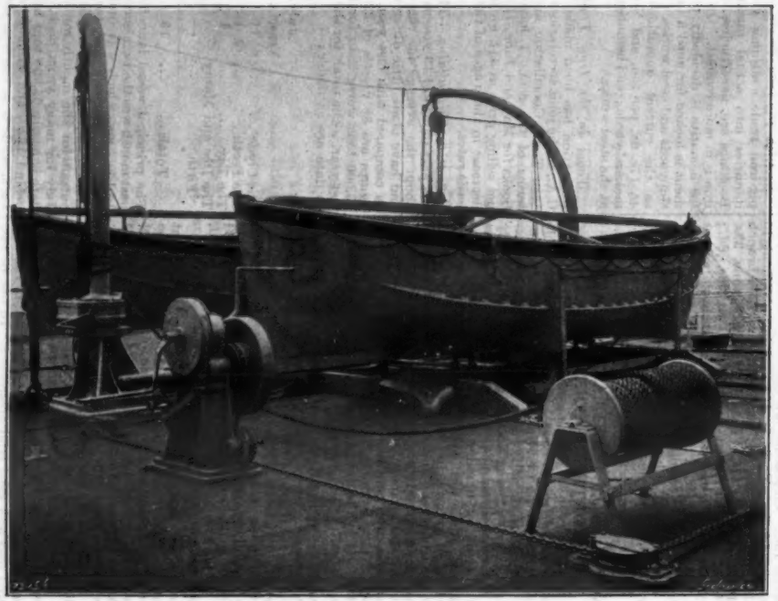


Fig. 3. Traversing Gear for Inboard Boats.

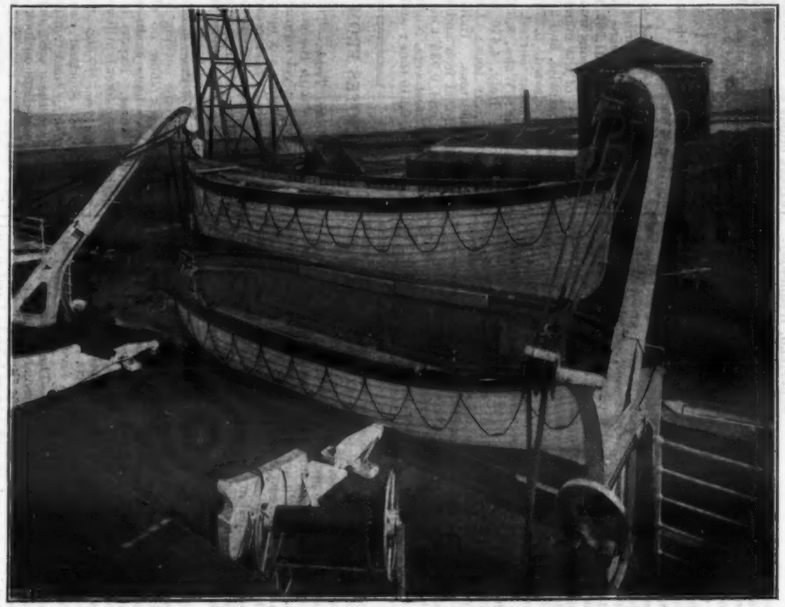


Fig. 4. Two Boats Suspended from One Pair of Davits.

ENGINEERING.

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One Two-Page Plate and Two One-Page Plates.—THE LJUNGSTRÖM TURBINE-DRIVEN LOCOMOTIVE.

ENGINEERING.

FRIDAY, AUGUST 4, 1922.

THE ELECTRICITY FINANCE BILL.

ALTHOUGH one of the chief needs of the time is that governmental and other public bodies should both spend and borrow less money, it would not be reasonable to attack the new Electricity Bill on this score. Certainly the chief purpose of the Bill is to allow joint electricity authorities to borrow money, issue stock and generally run up loans, but such authority had to be given unless the Electricity Act of 1919 was to be little more than a dead letter. The objection to the inflated expenditure of many public bodies at the present time is not to the principle of public bodies spending money, but to spending for which no reasonable return appears to be received. There are authorities spending twice, or more than twice, what they did a few years ago and yet from which the public does not appear to be receiving any better, or more extended, service. In the case of this matter of electricity supply one trusts that the money borrowed will be expended to good purpose and that it will actually prove a satisfactory investment. If it does it will assist the country instead of being a drag on it, as so much of the inflated public expenditure now is.

It will be remembered that the original Bill, which resulted in the Act of 1919, contained financial clauses which were withdrawn owing to Parliamentary opposition. The present Bill replaces these and gives a consistent body of legislation. That some financial arrangements are necessary hardly requires argument, but an excellent example of the impossibility of getting any effective work done without them is given by the case of the proposed Joint Authority for London. The number of interests concerned in the electricity supply of Greater London is so numerous that the difficulty of bending all to common action is of necessity very considerable, and it is greatly to the credit of the majority of the parties concerned and to the Electricity Commissioners that something approaching an agreed scheme was brought into being. The impossibility of real progress while any proposed joint authority had no power over finance was, however, well illustrated by the fact that the scheme as finally stated by the Commissioners depended on the contribution of funds by the associated companies, and immediately on the publication of the Commissioners' note a representative of the companies stated that any funds they were supplying must be subject to their control alone. As an essential assumption was that such funds should become those of the Joint Authority, it appeared possible that the scheme could not have gone forward. The giving of financial powers to the Joint Authority should alter the whole aspect of the matter, and one may trust that at least one difficulty is removed.

It was probably wise to drop the financial clauses in connection with the main Bill, as at one time it appeared possible that the whole scheme for organising and controlling the electricity supply of the country might be lost, but the time which has elapsed between that withdrawal and any real attempt to carry an additional financial Bill has been the subject of frequent criticism. This delay has no doubt largely been due to political considerations which had no particular concern with matters of electricity supply, but it is possible that some one intimately concerned may have realised that an educative interregnum might do no harm. The passing of the Electricity Act of 1919 without any financial clauses was never a very reasonable proceeding, but many people are not always reasonable, especially when their prejudices are concerned, and those in charge of the Bill may have thought that a little experience of the absence of financial provisions in the working of the general scheme would do the opposition no harm. If there has been any idea of this kind it has justified itself, as the new financial Bill has been got through without any great difficulty. The new Bill is, of course, not a mere repetition of the financial clauses of the old, but with reason and judgment on both sides the original proposals might have been modified to any extent. However, the delay has done little harm and has enabled the Electricity Commissioners to get through a very large amount of spade work of a general educative kind in making those likely to be connected with joint authorities realise what is expected and required of them.

The new Bill is in essence of a simple character. It gives power to Joint Authorities to borrow money with the consent of the Electricity Commissioners and subject to regulations to be made by the Minister of Transport. Money borrowed may be used for payment of the purchase price of any generating station or main transmission line which may be acquired, or for payment for any permanent work which an authority may require to undertake. Money may also be borrowed to provide working capital. Any money borrowed must be repaid within a period not exceeding sixty years. When a joint authority is constituted a limit is to be set to the maximum amount of money which may be borrowed and power to exceed that sum can only be obtained by an order of the Electricity Commissioners which has to be confirmed by the Minister of Transport and by Parliament. Money may be raised by the issue of stock, and, subject to the consent of the contracting parties, generating stations and other works taken over may be paid for in such stock.

Money may be raised in the open market, but it is likely that to a considerable extent the joint authorities will have to rely on the authorised undertakers and others concerned for their funds. Such authorised undertakers, local authorities receiving a supply of electricity from the joint authority and any borough or county district in their area which has a population of not less than 50,000, may lend money to the joint authority, subscribe to its stock or guarantee payment on loans. In the case of county councils and county boroughs, or districts, these provisions are hedged by the condition that the powers shall not, except in the case of the London County Council, be exercised without the consent of the Minister of Health. Further, in the case of councils which are not authorised undertakers, the annual liability must not exceed the proceeds of a penny rate, and

in the case of authorised undertakers must not exceed the capital charges from which the council will be relieved. The Electricity Commissioners and their staff form a comparatively small body, and one trusts they may remain a comparatively small body, but there are naturally expenses in connection with their activities which have to be met. They have been carrying on up to the present by a grant made in the Act of 1919, but in the future their expenses are to be met by demands on joint electricity authorities and authorised undertakers which will be apportioned in accordance with the number of units of electricity sold.

The above is a summary of the main financial provisions of the new Bill and constitutes its important features. It will be obvious, however, that the solvency of joint authorities is a question closely allied to any question of raising money. This solvency is not guaranteed by the Bill as naturally it cannot be, but power is given to any authority to fix the selling price of electricity so that over a term of years income shall balance expenditure plus a margin to be fixed by the Commissioners. If there is a deficit in any year that cannot be made up in succeeding years by an adjustment of prices, it is to be apportioned among the authorised undertakers. In connection with the matter of selling price, the ordinary period of revision of maximum prices is fixed at three years. This has previously been five years, and although in an era of rising prices a long period before revision is possible may be popular with consumers, it is obvious that rigid conditions of this kind may at any time prove inconvenient and may land authorities in serious difficulties. The matter also works both ways, and one trusts that the next few years may permit of maximum price adjustments in the consumers' favour.

In addition to these financial matters, which are the main features and purpose of this Bill, opportunity has been taken to put through various modifications and additions to the main Bill which experience has shown to be desirable. There is, for instance, a clause which enacts that consumers taking what are merely stand-by supplies shall pay a minimum annual sum which will secure a reasonable return on the capital charges incurred in providing for such supplies. Another clause, which in certain cases may prove of importance, allows the owners or lessees of a railway generating station to supply to a joint authority, an authorised undertaker or a consumer, subject to the consent of the Commissioners and to that of any power-company or authorised undertaker in whose area the supply is to be given. It was ridiculous that a customer should not be able to get a supply from a convenient railway power station even if he could not obtain a convenient supply from anyone else, and the insertion of this clause shows a growing appreciation of the fact that the real purpose of these various Electricity Bills is to help consumers to get a cheap and convenient supply of electricity, and that the object is not merely to build up a lot of complicated authorities to provide jobs for accountants and clerks.

THE LAW OF TRADE UNION MEMBERSHIP.

By an interesting coincidence the House of Lords gave judgment in two important trade union cases arising out of the participation of certain workmen in Messrs. Lever Brothers' so-called co-partnership scheme, on the same day (July 28) on which proposals for the further development of the scheme were made by Lord Leverhulme at a large meeting of the firm's employees. The two cases (Braithwaite *v.* the Amalgamated Society of Carpenters and Joiners and certain of its officials, and Ashley *v.* the General Union of Operative Carpenters and Joiners, &c.) were fully discussed in an article on page 752 of our issue of June 17, 1921. To put it shortly—the Court of Appeal granted an injunction against certain officials of the societies to prevent them from expelling the plaintiffs by reason of their participation in the co-partnership scheme. The societies appealed to the House of Lords, and contended (1) that the actions should not be entertained by the Court, and (2) that the rules of the societies justified the proposed expulsion. In the first branch of their argument the societies maintained that the actions were, in effect, actions to enforce the contract between their members themselves, and that as the objects of the societies were in restraint of trade the actions could not be maintained. Lord Buckmaster pointed out that a claim that a man possessed certain rights of membership was one thing, and an attempt to enforce them was another. The plaintiffs were seeking merely to get the courts to declare their right to remain members of the societies, and, incidentally, to prevent the societies from depriving them of their rights by expelling them; but they were not attempting to enforce the rights which membership would give them. There was accordingly nothing to prevent the court from entertaining the actions. On the second part of the argument, viz., the construction of the societies' rules, he held that the plaintiffs, by partaking in the so-called co-partnership scheme were not in any way infringing the rules of the societies.

The rule on which the Amalgamated Society of Carpenters and Joiners founded their case was one which gave the society power to expel any member who worked on a co-partnership system which provided for the operatives holding only a minority of the shares in the concern. Under Messrs. Lever Brothers' scheme workmen of not less than twenty-two years of age who were of good character and had been in the service of the company for not less than four years had an opportunity of being nominated, in the discretion of certain trustees, for certificates entitling them to receive a share in the profits on the company's ordinary shares. His Lordship held that the society's rule seemed to contemplate the allotment of shares, and in his view Messrs. Lever Brothers' system made no provision for the allotment of shares. It was true that the trade unions, looking to the care of their members, thought it best that the interests of employers and employed should be kept distinct, and the rule had no doubt been framed for that purpose, but it could not be stretched to cover the exact circumstances which had arisen. The General Union of Operative Carpenters and Joiners founded on a rule to the effect that any member who worked on a premium bonus system could be expelled. His Lordship said that the only definition offered of premium bonus included the idea that the bonus was a reward bearing a direct relation to work done. There was nothing of this kind in Messrs. Lever Brothers' system, and the rule, therefore, could not apply. Lords Atkinson, Sumner and Wrenbury delivered opinions to the same effect, and Lord Carson concurred. The societies' appeals were therefore dismissed, and the judgment of the Court of Appeal that the plaintiffs were entitled to an injunction remains in force.

The judgment, so far as it pronounces on the proper construction of the societies' rules, is of interest chiefly to the societies concerned; but on the question of the Court's right to prevent a member of a trade union from being wrongfully expelled, it settles a vexed question and shows that trade unions are not altogether beyond the power of the law.

THE REFRIGERATOR CAR.

In a good many countries where the distances are greater, the efficiency of the refrigerator car is of more importance than it is here. In many such countries our designers and builders are directly interested, though they lack unfortunately the first-hand information of the behaviour of such cars in service which is available to constructors, in, for instance, North America, where the records show some 153,000 of these cars to be in use. Probably in no country has the refrigerator car developed into so essential an adjunct of life as in America. In the United States, in particular, the wide range in climatic conditions from the warmth of Mississippi to the cold of Minnesota, or the heights of the Nevadas or the Rockies to the sands of Arizona, renders the transport of perishables a most complicated question. In countries like Ceylon, India and Egypt the service these cars have to perform is relatively simple. Providing the insulation is sufficient it is not difficult to arrange to keep meat frozen till delivery at the end of a comparatively short journey, in spite of the large diurnal range of temperature often met with in the tropics. In the United States a much wider range of perishables is habitually handled, while a single journey which may extend to from ten days to a fortnight, may involve traversing cold summits of mountains passes, and within a few hours running over scorching desert plains. The general demand of the markets for a season spread over as large a part of the year as possible introduces further complications.

Take as an instance the comparatively simple case of the apple crop. In the early season refrigerator cars, with or without ice, may be required. In the early middle season the fruit can be safely shipped in ventilated cars, or ordinary box cars provided with ventilation. In the latter part of the season the fruit has to be protected in refrigerator cars from the cold, and even artificial heating may be required. The care and elaborate organisation devoted to perishable traffic has made it possible for the dwellers in practically any of the large cities of the United States to indulge in almost any more or less seasonable product of the country. The distances covered are enormous, and the time occupied, as we have seen, is considerable. We have nothing comparable with it in this country or even in the Empire.

The conditions to be faced are more difficult than in transport by sea, in which case provision is made for the mechanical production of refrigeration during transit, and outside changes are less rapid. It is usually easier to arrange on shipboard for adequate insulation, and the construction is not required to combine lightness with resistance to jarring and jolting, to the extent so essential in railway equipment.

In an article on this subject in these columns in 1910* we gave some account of the different conditions which may be required to be met for various classes of meat, dairy products, fruit, fish, and so on. When it is realised that the endeavour has to be made to maintain carloads of these at their own appropriate temperatures over long journeys, with only a few degrees variation if the shipment is to be delivered in a sound and satisfactory state, the care necessary will be appreciated. Many classes of traffic are impaired as readily by too cold a temperature as by one too warm, and in most cases protection has to be arranged against too close a contact with the freezing agent, as well as from moisture resulting directly or indirectly from the refrigerating process.

The usual type of refrigerator car used in America is a box car about 40 ft. long over headstocks. This, with an ice bunker at either end of the car, allows about 33 ft. clear inside for the lading. Greater length has sometimes been adopted, but not with any conspicuous improvement. Extra length was tried with a view to securing more uniform temperature with the lading not stacked so high, but the circulation seems to have been affected adversely. In general, automatic thermal circulation is encouraged in the closed car. The air after cooling by contact with the ice, sinks to the floor and spreads down the length of the car below a grid. As the temperature rises again this air ascends through the open stacked lading, and on approaching the ceiling the current trends back towards the bunker to replace the air sinking through the latter to the floor. With too long a car there is apt to be comparatively warm motionless air in the centre of the car; the cold air does not extend through the whole stack and the upper parts of the interior are liable to be too warm.

The circulation is assisted not only by the grid floor, but also by bulkheads which cut off the ice bunkers from the rest of the interior. These bulkheads extend from a few inches above the grid floor to within some inches of the roof. They are of an insulating character, embodying felt, fibre or cork between boarding, and thus protect the goods close to the bunkers from damage due to being too near the ice. Thermal circulation alone is not found to be altogether satisfactory, since for the movement to be considerable the temperature differences have to be relatively large, and these, of course, are to be avoided, as part of the lading

* Engineering, vol. xc, page 21.

would then be too cold and other portions too warm. Ventilation is used therefore to assist the air movement in a car in transit, and very carefully drawn up instructions are worked to, based on a good many investigations, some of which have revealed rather peculiar facts. Among the more recent work in this connection may be cited a series of tests carried out by the United States Department of Agriculture. These actually in the main related to the use of ordinary box cars for the shipment of fruit, but they included work on a refrigerator car for the purpose of comparison. The tests included measurements with anemometers and the tracing of air currents by means of smoke released at various points. The standard refrigerator car has covers in the roof over each bunker, hinged on the side nearest the middle of the car. When partly opened, therefore, these covers form deflectors, and one would imagine that they would direct the air encountered by the car in its forward progress, down through the bunker into the car. The movement, however, is not so simple, and from the smoke tests it appears that when both covers are partly open, air is actually drawn in at the rear ventilating hatch and passes forward to be expelled at the front hatch. The air both above and below the lading moves in the same direction, from which it would seem that under these conditions the front bunker serves chiefly to cool the outgoing air.

As is well known, the conditions the structure of refrigerator cars has to withstand are severe. The cooling process always involves moisture from ice or brine. The latter agent appears now to be falling into disfavour owing to its effect not only on the cars themselves, but also on metal work of the permanent way with which it may happen to come in contact. The woodwork and insulation of the car is always liable to deterioration from moisture. In the case of meat traffic the suspension of the load from the roof, and the swaying set up on the road, further imposes severe wracking stresses on the structure. A paper read recently by Mr. W. H. Winterrowd before the American Society of Mechanical Engineers gave some interesting details of the present trend of American refrigerator car practice. In this paper Mr. Winterrowd lays great stress on the need for thoroughly protecting the insulation and woodwork from moisture, and of keeping the insulation intact.

With regard to type of structure, the steel underframe is now almost universal, while metal roofing is also widely adopted. Steel is also coming into vogue for body work, and great care is exercised in such cars to ensure watertightness, by welding joints and so on. Whether the structure be of wood or steel, effective insulation is essential. The general tendency in regard to this is clearly towards the massing of the material, instead of adopting successive layers or linings separated by air spaces. Present practice undoubtedly favours the concentration both of the material and of the air spaces, while waterproofing receives much more attention than formerly.

For the sides, which, in wooden cars, run to about 6 in. thick, at least 2 in. of insulating material are used, while the air space will be about that also. With outside match-sheathing $\frac{3}{4}$ in. thick there usually comes next on the inside some waterproofing material. Next there is the insulation, the 2-in. thickness being made up of layers from $\frac{1}{2}$ in. thick upwards. Then comes another waterproof lining and then $\frac{1}{2}$ in. boarding. Next to this is the 2 in. air space, more waterproof fabric or paper lining, and finally the inside wood lining of about $\frac{13}{16}$ in. match boarding. It is as important that the insulation should be maintained intact, as that it should be kept free from moisture. Failure in either of these directions means impaired heat-resisting properties. It was the difficulty of preventing air leakage and consequently circulation of air in the cellular construction formerly adopted which caused that system to be abandoned. Since then two schools have developed. One, apparently the larger, advocates placing the massed insulation next the outside sheathing and the air space next the inside lining. The other reverses the positions. The argument in the first case is that nails are often driven into, and damage is often done to, the inside lining, in loading, and if placed towards the outside the insulation is less liable to be broken down. In the second case it is held that in service and in yard working, the outside is frequently damaged and the insulation if placed outside is very liable to be destroyed, while it is afforded greater protection if placed inside. On the whole, the "inside" school, though in the minority, would appear to have the stronger case, since loading in such cars is supposed to be completed with spacers, &c., and damage by nailing is held to be avoidable, while accidental happenings outside cannot be so well guarded against.

The roof usually incorporates three wood linings under the metal covering—the sub-roof, an intermediate false roof, and the inside roof or ceiling. As in the walls, the insulation is massed between two of these, the space between the other two being left for air. As also in the case of the walls, opinion appears to be divided as to whether the insulation should be arranged next the sub-roof or next to the ceiling; on the whole the former is most favoured. No objection appears to be raised against the metal roof, providing sufficient insulation is arranged with it.

The treatment of the floor shows greater variety. The inside flooring is commonly $1\frac{1}{2}$ in. wood. Below this is frequently placed a 2-in. layer of cork, or cork boards aggregating 2 in.; under this again is $\frac{7}{8}$ in. outside flooring. Below and above the cork is laid waterproofing compound, or a paper preparation and a $\frac{1}{2}$-in. layer of asphalt. Sometimes the cork and asphalt protection are carried some little distance up the sides, where, up to a height of 12 in. or so, they replace the felt or other insulating material employed for side protection. This is done to avoid damage from moisture, though it is recognised that both from the insulation and maintenance points of view leaks are better avoided altogether. Although a number of special insulating preparations are in use, hair felt and cork are the most commonly applied insulators for walls, roofs and flooring, with prepared paper waterproofing. As granulated cork disintegrates in time, cork boarding is sometimes adopted in lieu.

The attention required by cars *en route* depends largely upon the effectiveness of the insulation, as well as on the condition of the load. In order to reduce the amount of re-icing required, pre-cooling of both car and of the lading is largely adopted. At many of the large shipping points the freight is treated in cold stores before loading. At others the loaded car has cold air at a temperature of 12 to 20 deg. passed through it for four hours before being finally iced and started on its journey. In the case of products frozen hard, little icing is required on the road, the freight supplying its own refrigeration. Everything is done to bring about the rapid cooling of the contents of the car, but where shipments are small and frequent at wayside stations, satisfactory conditions are very difficult to maintain.

TYPE FACES AND LEGIBILITY OF PRINTING.

APPARENTLY the House of Commons is apprehensive that the deliberations and decisions of that assembly will not secure from the public the attention they deserve, owing to the unattractive form in which they are published and the disregard of the niceties of typographic display. On a recent occasion, His Majesty intimated to the London County Council that what is "meanly housed may be meanly esteemed," enforcing the wisdom of attention to external appearances. It would seem that the House of Commons, animated by a due regard for the truth of this precept, is anxious that the credit and influence of their deliberations and resolutions may not suffer from inattention to the form in which they are published. It would be very regrettable if by reason of inferior typography or inartistic display the wisdom of our legislators failed to receive the attention to which it is entitled. To prevent such a perverse contingency a Committee was recently appointed under a Treasury Minute, "to select the best faces of type and modes of type display for Government printing, having regard to appearance, ease in reading, and economy." The Committee, under the chairmanship of the Rt. Hon. C. W. Bowerman, M.P., have accepted their duties very seriously, have held 27 meetings, and expended a little over 1,000*l.* (in which sum is included the cost of production of 1,000 copies of their Report)* in order to advise the House of Commons on this important matter.

The result of the Committee's deliberations is embodied in 15 recommendations or conclusions, to the more interesting of which it is proposed to call attention.

The side issues raised in such inquiries, however, are apt to prove as instructive as the main topic debated, and in this instance the whole problem of the factors that tend to promote legibility in printing has been raised and discussed in a very illuminating manner by Mr. L. A. Legros. The Committee have been very fortunate in obtaining this note,† which manifestly has a very wide application, and they gratefully admit that the information supplied has been of the greatest assistance in their deliberations. The determination to give this note a wide circulation has been well taken and should be fittingly acknowledged. It supplies much of the evidence on which the Committee have based their decisions.

Most of us, while conscious of the beauty of a well-printed page, and of the unfavourable impression produced by indifferent typography, have made no attempt to examine the operating causes that distinguish one from the other. We take no note of individual letters, for the eye and brain have been unconsciously trained to grasp several characters in combination, and to recognise only complete words or phrases. A very critical judgment is necessary to detect the minute differences possible within the outline of a single letter, but to insist upon some slight deviation from accepted rules might decrease or impair legibility. So little attention is paid to detail, that many have never noticed that the left-hand limb of the capital letter M is not so thick as the right-hand limb, and that this difference of thickness does not obtain in the vertical strokes of the capital N. This disregard for minutiæ explains in some measure the small attention given to the systematic effort to increase legibility, for we have not appreciated the part played by the individual letter in the total ideograph. Mr. Legros states that notwithstanding the changes made in the forms and styles of type during the four and a-half centuries that have elapsed since movable types were first employed in England, only one definite change has been made with the deliberate intention of increasing the legibility of the Latin characters. This one change is the abolition of the long *ſ* which so closely resembled the *f* that it was very difficult to distinguish one from the other. The history of typefounding affords a strong proof of the innate conservatism of the human mind, for though this change was advocated in 1749, and actually introduced, with due apology, in 1787, the abolition was not complete till 1824.

Such opposition to innovation does not invite suggestions, and long familiarity with existing usage, makes extensive alterations undesirable. To the expert, however, the opportunities for improvement are many, and Mr. Legros indicates no less than 23 directions in which examination might prove profitable. Some of these, however, as the translation of the ideographic picture by the brain are of a subjective character and outside the domain of the typographer. The House of Commons Committee have, however, ample scope for their deliberations in determining apparently such small details as the proper size of the characters, the thickness of the strokes forming these characters, the amount of white between the letters, or in the "counters" of the characters themselves, in spacing the lines, in selecting the most suitable length of the printed line, and in effecting the separation from adjacent matter, besides many other technical points of which the public judge only by the general effect. In the exhibition of tabular and statistical matter, into

* Report of the Committee to Select the Best Faces of Type and Modes of Display for Government Printing. London, 1922. Printed by H.M. Stationery Office. Price 4*s.* net.

† A Note on the Legibility of Printed Matter: Prepared for the Information of the Committee on Type Faces, by LUCIEN ALPHONSE LEGROS, O.B.E., M.Inst.C.E. London, 1922. Printed by H.M. Stationery Office. Price 1*s.* 6*d.* net.

which figures necessarily largely enter, another class of questions enters, concerning the proper width of the figures, the relative advantages attending uniformity or variation of size, the method of printing vulgar fractions, the use or the omission of the solidus, while the quality and tint of paper, its light-reflecting capacity, the colour of the ink and decorative effects generally offer so many opportunities for disagreement, depending as they do upon the exercise of individual taste and judgment, that unanimous decision seems well nigh impossible.

The Committee protect themselves by pointing out that the conditions which contribute to legibility "are so many and involve so many questions of traditions and use, that it is not possible to frame a series of statements which will hold good on all conceivable circumstances and be true if taken each by itself." And, further, the Committee recognise, that certain disputed or unsettled problems, connected with legibility and the optical properties of paper and ink with reference to eye strain, would best be remitted to the Medical Research Council, who have facilities for conducting research on physiological and psychological lines. The conclusions must not be considered as final or universally applicable, but relate simply to the conditions of Government printing and any inferences drawn must be subject to that limitation.

After careful examination of many specimens of type selected from the styles known as "old face" and "modern face," the Committee decided to recommend the uses of the "old face." In the form preferred, the letters are as simple as possible; and the face is broad in comparison with that of the compressed form. Undue thickening and thinning of the serifs and strokes are avoided, and the whites between are not reduced. It is admitted, however, that a number of modern face type are available which are free from the violent contrast between the thick and thin strokes, flat serifs and marked lateral compression, common defects in this type. Mr. Legros has attempted to reduce to a numerical scale the relative legibility of the old and modern face types in those instances in which several of the parts closely coinciding as in c–o, e–o, c–e, &c., might lead to confusion. Measured in the scale adopted, he finds that the mean specific legibility of pairs of letters of approximately similar outline is, in the case of old style face, represented by 3·21. With a modern face of the same gauge and blackness, this figure becomes 2·8, and in sans-serif 2·2. Of course, exception can be taken to the method of measurement, which is effected generally by superposition, and the effect of the surrounding letters on a page of print is disregarded, but it seems to dispose of the claims of the sans-serif, a face that has an unbroken outline, resembling the earlier form of letters incised in stone. A fiction has long prevailed that the serif is an undesirable ornament and that legibility would be increased by its disuse. But this is an error, the absence of serifs actually increases the resemblance between some letters as *i* and *l*, and in others the whites are made narrower, a defect that is not possible in those styles where the presence of the serif ensures the provision of adequate white "counters."

The sure and easy recognition of figures is perhaps of greater importance than that of letters, for in reading the eye habitually recognises combinations of letters at a glance, a kind of corrective influence is exercised by the context, but there is no such assistance in reading figures. Each digit has to be identified separately. Little has been done to produce more legible figures, and though many specimens are reproduced in the report, and some which have been purposely designed with the view of increasing the legibility, it will probably be felt that no one set gives complete satisfaction. The Committee state, and no surprise will be felt at the admission, that enquiries made among those habitually dealing with tables of figures have revealed an astonishing diversity of opinion on the vexed question of legibility. There are only 10 forms required to express any number or combination of numbers, but it seems to pass the wit of man to design type faces of such distinctive forms that no two or more can be confused, if the eye is not to be offended by the presence of long ascenders or descenders. Beset by contradictions the Committee prudently fall back on the Medical Research Council as being the body best fitted to arrive at a satisfactory decision on the many disputed points. As a temporary measure, the use of modern face or modernized old style is recommended as possessing the fewest objections, especially if care is used to select a series in which the counters are sufficiently open to reduce the possibility of confusion to a minimum. Mr. Legros, in pursuing the same method of determining the specific legibility of figures that was applied to letters, finds that for the various styles the mean legibility is represented by the following figures:—Modern, 9·31; old style, 6·97; Blackfriars, 4·39; and sans-serif, 4·82. Both authorities agree in recommending that in body sizes up to eight-point recourse should be had wherever possible to figures cast on the two-thick-space set. An example shows the superiority of this plan. It must not be forgotten, however, that the clearness or facility in reading does not depend on the size of the type alone, but on the proportion of the type to the interval between the lines.

The covers and title pages of Government publications have received considerable attention, and the decisions are of value in all matters of display printing, wherein individual taste is apt to exhibit sad eccentricities. The recommendations governing arrangement are quite sound, and will obtain general assent. The suggestions aim at increased simplicity of design, by confining the type to one fount and of the same family as the letterpress, and to using few sizes of type, varying in size with the importance of the information to be conveyed. To guide the public taste, the Report shows several examples of covers and title pages of official publications as at present displayed, and at the same opening the matter reset, with closer regard to the correct principles applicable to the composition of such pages. On the reset pages, the Royal Arms present a noble appearance on which the Committee may be congratulated. These arms are intended for ornament and, therefore, they should be ornamental, but the smaller designs are "at the best apt to be a blur of confused detail, and at the worst an unsightly blot on the page." The discreditable appearance is probably due to a reduction by a mechanical process, disregarding the fact that it is not possible to reduce drawings proportionately, for a larger range than two-thirds the original intended size, and at the same time preserve clear printing. The light and shade require different treatment in translation with diminishing size. The Committee are on safe ground in recommending that if a drawing is to be reduced to less than two-thirds linear of its size, the details should be redrawn to suit the reduction contemplated.

VANADIUM AND ITS METALLURGICAL USES.

Amongst that most useful group of metals which of late years has become of great importance as alloying elements in special steels, vanadium takes a prominent place. The compounds of vanadium have long been known and used, but no use for the metal was found until the discovery of its great value as a steel ingredient.

Vanadium metal is a silver-white lustrous metal with an atomic weight of 51·2 and a specific gravity of 5·5. It is not appreciably affected by air at atmospheric temperatures, but burns with brilliant scintillations when its powder is thrown into a flame, and also burns vividly when heated in an oxygen atmosphere. Vanadium is non-volatile at high temperatures, decomposes water at 100 deg. C., is not affected by hydrochloric acid but is decomposed slowly by hydrofluoric acid, evolving hydrogen, and is readily dissolved by nitric acid. It forms five oxides analagous to the five nitrogen oxides and shows both basic and acid properties in different compounds. Thus, while it forms vanadates with a number of the more basic metals such as potassium, sodium, barium, calcium, strontium and lead in which it behaves as an acid, it also forms salts such as the chlorides and sulphates in which it functions as a base.

Vanadium compounds have so far found only limited employment industrially and the use of the metal is practically restricted to the one purpose of alloying with special steels, which, however, is an exceedingly important application.

Vanadium ores occur under a great variety of circumstances, but in no known instance have they segregated into large deposits such as are characteristic of some of the better known metallic ores. But, so far as the general distribution of the element is concerned, vanadium can scarcely be regarded as rare. Mr. W. F. Hillebrand, of the United States Geological Survey, in making a special study of vanadium occurrences in the earth's crust, found that in 57 different igneous rocks it was present in appreciable, and in most cases weighable, quantity. In a composite of 230 sandstones, the percentage of vanadium was 0·003 and in a composite of 498 limestones the percentage of vanadium was 0·004.

The ore minerals of vanadium which have so far been the source of commercial vanadium are patronite, the sulphide; vanadinite, descloizite and related minerals found in the oxidised parts of lead and copper veins; carnotite, a hydrous potassium-uranium vanadate; and roscoelite, a vanadium mica. But many other sources of vanadium are known in some of which the identity of the vanadium mineral has not been ascertained.

An occurrence of vanadium was noted by J. J. Kyle in lignite from San Rafael, Province of Mendoza, Argentina. This material yielded only 0·63 per cent. of ash, but of this 38·22 per cent. was vanadic oxide.

A. Mourlot obtained 38·5 per cent. of vanadic oxide from the ash of a similar material from Yauli, Peru. In a sample of grahamite (a bituminous mineral with about 6 per cent. of ash), R. C. Wells found 12·2 per cent. of vanadic oxide and in the ash of an asphalt from Nevada, nearly 30 per cent. of vanadium pentoxide. Vanadium has also been found in French bauxite, cryolite, in rutile, in an Australian brick earth in sufficient quantity to give a distinctive colour to the brick made from it, and also in other Australian clays and shales. In Great Britain vanadium has been found in the ash of certain coals and in oil shales of Scotland, and in the form of mottramite, it has been found and worked to a small extent in Derbyshire. A vanadium occurrence in coal in Sweden is reported to be under exploitation in which the value of the vanadium in the ash far exceeds that of the fuel value of the coal.

Patronite is the most important ore worked at the present time. It furnishes about two-thirds of the world's total output of the metal and is found in commercial quantity only at Minasagra in Peru. At this place the ore body consists of a large single mass of asphaltic material of a roughly lenticular form in rocks of sedimentary origin. Large quantities of ore have been mined from this deposit in recent years, but while the lateral limits of the ore body have been reached, there is no apparent sign of the ore being exhausted in depth.

Carnotite, the next most important ore of vanadium, is found and worked in the south west part of Colorado and the south eastern part of Utah. The mineral occurs as a replacement in sandstone beds of wood or other vegetable matter now fossilised, and also as an impregnation in the sandstone. Roscoelite occurs under similar conditions to carnotite, sometimes as a subordinate mineral to the carnotite, but in other cases as the only vanadium mineral present, and this also is obtained in Colorado and Utah. Small quantities of dechinite and other oxidised vanadium minerals are obtained from New Mexico, Nevada and Arizona, but these are unimportant.

Year.	Peru.		United States.
	Vanadium ore.	Vanadium content.	Vanadium metal.
1915	3,145	803	627
1916	3,448	772	460
1917	4,083	821	484
1918	2,183	234	276
1919	—	300	247
1920	—	—	510

Peru and the United States are responsible for practically all the vanadium produced. The production

from these two countries in recent years in short tons is recorded in *Mineral Industry* in the foregoing table:—Practically the whole of the vanadium production of the world is controlled by the American Vanadium Company, whose works are in the United States. This country absorbs the greater part of the output; England, France and Germany take a comparatively small proportion.

The reduction of vanadium from its ores is often complicated by the presence of other economic constituents which have also to be recovered. This is particularly the case with carnotite ore where the primary constituent is the radium, which always accompanies the uranium in the ore, and from which the uranium also is usually saved.

The recovery of vanadium from the mixture of patronite and asphaltic material found at Minasagra in Peru is accomplished by first roasting the ore in a reverberatory furnace which has a capacity of 80 tons of ore. The time occupied in passing the ore through the furnace is about two days, this somewhat long period being necessary to burn off completely the asphaltic constituent. The ore is self-burning except that a little coal is necessary in the final stage of the roasting to raise the temperature sufficiently to drive off the sulphur. The roasted product contains 40 per cent. to 50 per cent. of vanadic oxide and not more than 0·5 per cent. of sulphur. The roasting process is carried out in Peru; the subsequent treatment to obtain the metal or ferro-vanadium is carried out in the United States.

Another method is to roast the crushed ore with salt or some other sodium compound which results in the formation of sodium vanadate.

This compound is freely soluble in water and can therefore be extracted from the insoluble portion by leaching and filtering. The sodium vanadate is either treated with hydrogen sulphide to precipitate the vanadium as sulphide or with ferrous sulphate to precipitate iron vanadate. The sulphide is filtered off, dried and calcined to oxide, from which the metal can be obtained by reduction as described below.

The iron vanadate precipitate is also filtered off, dried, and reduced to ferrovanadium carrying 35 per cent. to 40 per cent. of vanadium.

The vanadates of lead copper and zinc, which constitute the ore minerals of some other deposits, can also be treated by this latter method. In the roasting stage, the lead is reduced to metal and is separated as such. The copper and most of the zinc remain as insoluble compounds when the roasted material is leached with water, leaving a solution containing sodium vanadate chiefly.

In the treatment of carnotite ore in which radium and uranium as well as vanadium are present, it is necessary to use a process which will recover all three of these constituents. The ore is boiled with hydrochloric acid in earthenware vessels and from the mixed chloride solution thus obtained, radium is precipitated by the addition of small quantities of barium chloride and sulphuric acid. Barium and radium sulphates are formed, and the relatively large precipitate of barium sulphate brings down with it the very small proportion of radium sulphate, leaving the uranium and vanadium in solution. From this solution the uranium and vanadium can be precipitated separately by appropriate means, the vanadium usually as vanadate of iron.

Very little vanadium metal is produced as such, but if it is required the oxide is mixed either with carbon or aluminium powder and reduced, either in crucibles or in an electric furnace.

For use in steel alloying, vanadium is usually added to the steel in the form of ferro-vanadium which is obtained in one of the following ways:—(1) By the reduction of mixed ferric and vanadic oxides by aluminium (thermit process); (2) by the reduction of vanadate of iron mixed with carbon in an electric furnace; (3) by the reduction of pure patronite mineral mixed with lime and carbon in an electric furnace. Reduction with carbon results in the alloy containing an excess of carbon which has to be removed by refining with either ferric or vanadic oxide. The reaction in this refining process is the combination of the carbon in the molten alloy with the oxygen of the added oxide, and the reduction of the latter to metal.

The minor uses of vanadium are comparatively unimportant. Small quantities are used in dyes, as medicines, for one or two chemical re-agents, and a few other purposes. As already stated, the main use of the metal, accounting for upwards of 90 per cent. of the vanadium produced, is as a constituent of vanadium steel. Vanadium owes its great economic value to the fact that when added to steels in quantities ranging from 0·05 per cent. to 0·50 per cent., it removes occluded oxygen and nitrogen, and combines with the steel to the very great improvement of its physical properties. In the smaller proportions, it confers great toughness to steel, making it particularly well adapted for automobile axles and other parts subject to excessive stress. In larger proportions it is used in high speed and other tool steels to which it imparts certain desirable qualities which no other known substance can give in an equal degree. This fact has led to its becoming a standard constituent of such steels. Nearly all the vanadium in such steels is found in the pearlite as a combined carbide of vanadium iron and any other metals present.

—	A.	B.	C.	D.	E.	F.	Iron
Carbon	1·06	1·02	1·00	0·05	0·80	1·04	—
Vanadium	0·14	0·29	0·58	0·85	1·11	0·77	—
Aluminium ..	0·07	0·09	0·36	0·05	0·45	0·21	—
Elastic limit (tons)	43·00	43·20	64·80	20·40	54·00	52·80	12·00
Maximum stress (tons)	67·00	76·20	85·20	26·10	77·10	84·00	21·00
Elongation, per cent.	6·50	8·50	7·00	37·00	10·00	7·50	—
Red. in area, per cent.	6·90	10·00	7·60	72·00	17·60	9·30	76·00

The effects of adding vanadium to steel in varying quantities with a little aluminium as a deoxidiser was demonstrated by Dr. T. O. Arnold in 1915 and the results obtained are contained in a report published in the Journal of the Iron and Steel Institute of that year. The above table of the physical results obtained speaks for itself, but a few comments taken from Dr. Arnolds' report emphasising certain features of the results may profitably be added.

Comparing the tests on pure ingot iron with tests on D sample in the table, it will be noted that 0·85 per cent. of vanadium alone has raised the elastic limit 8 tons and the maximum stress 5 tons per square inch without appreciably affecting ductility.

A nearly pure steel containing 1·10 per cent. carbon has an elastic limit of about 30 tons and ultimate strength of about 60 tons per square inch, with an elongation in 2 in., and a reduction of area, each of about 8 per cent. It will be seen by referring to results with A sample in the table, that 0·14 per cent. vanadium has raised the elastic limit 13 tons and the maximum stress about 7 tons per square inch without any great change in ductility. In the tests on sample B, without any lowering of ductility, 0·3 per cent. vanadium has raised the maximum stress to 76 tons, and 0·6 per cent. has raised it to 82 tons per square inch.

There seems to be no advantage in adding beyond 0·6 per cent. of vanadium as the results of tests on sample F with 0·77 per cent. gave practically the same results as those obtained for sample C containing only 0·58 per cent.

Dr. Arnold concludes that the action of vanadium in steel resembles that of tungsten, but is from 10 to 20 times more powerful.

Vanadium used with other alloying agents in steel produces effects scarcely less remarkable. A steel on receiving an addition of 1 per cent. tungsten was found to have its elastic limit raised 5 tons and the maximum stress 14 tons per square inch. The same steel alloyed with 0·25 per cent. vanadium had its elastic limit raised thereby 18 tons and the maximum stress 30 tons per square inch. The addition of 0·25 per cent. vanadium to a steel containing carbon 0·25 and manganese 0·4 per cent. increased the elastic limit by about 13 tons and the ultimate stress 12 tons due to the vanadium addition. The elongation was also the very good one of 28 per cent. With a chrome steel, vanadium in small quantity increased the elastic limit 13 tons and the maximum stress 14 tons, and produced a material with 55 tons maximum stress and an elongation of 26 per cent.

In English high speed tool steels, the vanadium proportion is usually from 1 per cent. to 1·5 per cent., but German and American makers of such steels use somewhat less than 1 per cent. Prior to the war, high speed steels contained carbon, chromium, tungsten and vanadium in varying proportions but the vanadium proportion was not more than 1·5 per cent. While these steels were excellent materials for high speed tools, very much better steels have since been discovered practically all of which contain vanadium. An interesting development has been the subject of a British patent in which the inventor claims that 18 per cent. of tungsten can be replaced with advantage by 6 per cent. of molybdenum in the presence of a little over 1 per cent. of vanadium. In these steels vanadium is regarded as the key element, and its functions are described as stabilising the variable properties of molybdenum steel and the prevention of cracking during the water-hardening operation. The result is said to be not only a steel of remarkable hardness but also thermal stability. Moreover, it is claimed that this molybdenum-vanadium steel does not "let down" until a heat of 700 deg. C. is reached in which respect it is superior to most other steels of this class.

There seems to be no doubt that in vanadium steel under correct conditions of heat treatment, engineers and users generally have a material with quite exceptional qualities. The appreciation it has gained in engineering circles may be gauged by the fact that in 1916, about 800,000 tons of various kinds of vanadium steel were produced, and unlike some other alloy steels, its popularity seems to be on the increase.

A more general use of vanadium steel is unfortunately limited by the relative sparseness of vanadium ores which makes ferro-vanadium a somewhat costly alloying substance. But it is by no means improbable that intelligent prospecting will sooner or later reveal the existence of such ores in far greater abundance than now seems apparent. A few years ago the vanadium deposits on the United States were either unknown or little investigated, although to-day they are responsible for about one-third of the total production. It is therefore not unreasonable to anticipate that parts of the globe less thoroughly and less akilfully explored will be found to yield vanadium ores in commercial quantities. The value of vanadium has only lately been realised, and its appearance in mineral form, and the geological conditions under which vanadium minerals occur, have yet to be made familiar to the average prospector. Nevertheless discoveries of vanadium ore deposits in various parts of the world are not infrequent. It is interesting to note that at the Broken-hill lead-zinc mines in north-west Rhodesia, decloizite, a vanadate of lead, is present in some abundance in the oxidised portions of the lead-zinc deposits. While no commercial use has yet been made of this occurrence, it is reported that the vanadium bearing material already mined has been stacked pending arrangements for its disposal for its vanadium content.

In the Union of South Africa also, vanadium-bearing lead ore is found in quantities of commercial importance in a lead ore deposit near Zeerust. This ore deposit contains numerous cavities, the lining of which consists of vanadium minerals. A company has been formed with a substantial capital to work both lead and vanadium and an early production may be expected.

STANDARD SPECIFICATION FOR DIRECT-CURRENT COMMUTATOR BRUSHES.—The British Engineering Standards Association has issued as Report No. 96—1922, a standard specification for parallel-sided carbon brushes for direct-current commutator machines. The specification is divided into two sections referring to carbon and metal carbon, and to compressed unburnt graphite, brushes. Nominal dimensions and tolerances are specified. Copies of the specification may be obtained from the Secretary, 28, Victoria-street, S.W.1, post free, 1s. 2d.

BIRMINGHAM ELECTRICITY SUPPLIES.—During the year ending last March the Birmingham Corporation Electricity Undertaking sold 111,038,406 units as compared with 136,921,417 the previous year. The total sales were lower than any year since 1915, when the figure was 82,909,182. In spite of this fall in output the gross profit at 316,802*l.* was the highest ever realised. The average price obtained per unit was 2·252*d.*, as compared with 2·267*d.* the previous year. The lamp and motor connections were higher than they have ever been, the figure for 60-watt lamps being 424,001 h.p. and for motors 163,244 h.p.

HENRY VIII AND NATIONAL DEFENCE.

By A. W. Johns, C.B.E., R.C.N.C., M.I.N.A.

A speaker* at a dinner last year remarked that few were aware of the important part played by Bluff King Hal in the development of the British Navy. This remark is only too true, for Henry VIII is more generally remembered as our most married monarch, and it is concluded that his time was so fully occupied in marriages and their dissolution, that little could have remained for the more important affairs of his kingdom. Yet a glance through the State Papers appertaining to his reign shows him to have been a wise and far-seeing monarch, thoroughly conversant with all matters affecting his kingdom and initiating many of the most important developments. To an engineer—using that term in its most liberal sense—many of his activities are of the greatest interest.

His place as the founder of the modern British Navy has long been accorded him by naval historians. Other kings before him, notably Alfred and Henry V, made efforts to establish a navy worthy of their kingdom and to a certain extent succeeded, but their successors by indifference and neglect allowed it to decay. At his accession Henry possessed a Navy whose tonnage was between 2,000 and 3,000, but which included two fine ships, the Regent, of 1,000 tons, built in 1486, and the Sovereign, of 800 tons. A report by Phineas Pett shows that at Henry's death in 1547 the tonnage of the ships of the Navy was slightly over 10,000. Edward VI and Mary allowed it to decrease, but Elizabeth followed her father's example and at her death it exceeded 14,000 tons.

The early years of the sixteenth century witnessed important developments in warship design. Guns, which had been introduced on shipboard by the Venetians towards the end of the fourteenth century, had gradually increased in numbers on individual ships as the fifteenth century progressed. The calibre of the guns was relatively small, the majority being of a type known as serpentines, which fired shot of from 4 lb. to 6 lb. weight. Their positions were confined to the upper works, *i.e.*, the poop, forecastle, the upper deck and the tops on the masts.

The introduction of gunports between decks by a shipbuilder of Brest early in the sixteenth century facilitated a large increase in the number of gun positions. This and the development of larger calibres of guns on the Continent were the first steps in the production of a warship possessing a numerous and heavy broadside armament, a type which remained for over three and a-half centuries.

Henry VIII had the intelligence to appreciate these developments, and to recognise the necessity for a strong Navy for the defence of his island kingdom. He proceeded to take the requisite steps to organise this Navy, its administration and the dockyards and other establishments which it entailed. During his reign about 45 ships were specially built for naval purposes; 26, some of them Venetian and Genoese caracks, were purchased, and 12 were captured and taken into the Navy. Eighteen of the ships built and 19 of those bought exceeded a tonnage of 200. Nowadays a warship of such a tonnage is considered exceedingly small, but at the time it was relatively large. A return of the ships of the Eastern ports of England in 1544 shows the largest to have been one of 160 tons, belonging to Ipswich, whilst another return of 1572 of the merchant ships of the kingdom shows the largest to be one of 240 tons, followed by 13 of 200 tons, the great majority being between 60 tons and 80 tons.

The largest ship built by Henry VIII was the Henry Grace à Dieu, or Great Harry,† laid down in 1512 and completed in 1515. On completion her tonnage was given as 1,000, but in 1525 it was stated to be 1,500. At first she proved unstable under sail, and the fitting of girdlings to remedy this defect explains the increase in tonnage. Although complete details as to the names and wages of the workmen employed on her still exist, her dimensions were kept so secret that to this day they are not definitely known. Both Woolwich and Erith are mentioned as the place of her construction, but an entry of 6*s.* 8*d.* in the King's payments "as an offering at the Hallowing of the King's Great Ship at Erith" on June 13, 1514, defines the place of her construction and the date of her launch. She was one of the first "Great" ships with gunports between decks, and mounted 180 guns, of which 122 are described as serpentines. The Mary Rose, built on Southampton Water in 1510 or 1511, was another fine ship of Henry's Navy. In 1512 her tonnage was given as 500, and in 1525 as 600. In 1545 she mounted 85 guns, 33 of which were serpentines.

Concurrently with the growth of his Navy the king formed an administration to deal with its affairs. A clerk or "keeper of the king's ships and galleys" had existed since 1214, and at Henry's accession he was the only naval official except the Lord Admiral. Henry confirmed the holder of the post, Robert Brigandine or Brickenden, appointed in 1495, in his position. He was in charge of the building of the Great Harry, and had under him for the work William Bonde, Clerk of the Poultry, and William Crane, Gentleman of the King's Chapel, but the exact responsibilities of each are not recorded. According to one reference Brigandine designed the ship. He died in 1523 and was succeeded by Thomas Jermyn, Leonard Thorneton (1533), Edmund More (1538), Edward Waten (1540), Benjamin Gonson (1545), and Thomas Howlett (1545).

In 1514 another official was appointed as "keeper of the king's new storehouses at Deptford and Erith for the saving of the necessaries belonging to the king's ships." The first holder of this post was John Hopton, Gentleman Usher of the Chamber, merchant and shipowner. From him the king had purchased a "great" ship for 1,000*l.* in 1513, and a second, the Mary Glory, of 300 tons, in 1517. His appointment was a very early instance of the "business man" in State affairs. He died in 1524, and was succeeded by William Gonson, of Deptford, another merchant and shipowner who held the post until his death in 1544, when John Wynter, a shipowner of Bristol, was appointed to the vacancy. This office in Gonson's time was termed the "Treasurer for marine affairs," and, later, the Navy Treasurer. The original purpose of the office as defined in Hopton's appointment, was taken over in 1541 by another official, the clerk of the stores, who was placed under the Comptroller.

The "business man" does not appear to have been a marked success in administering the affairs of the Navy, for in 1524 a report, which is unfortunately now mutilated, complains of a lack of economy in many directions in naval matters. As a result, a new office was created in 1525, and Thomas Spert was appointed "Comptroller of the King's Ships," holding the post until 1541. Spert* was a naval officer of considerable experience, having been master of the Mary Rose and of the Great Harry, and holding an annuity of 20*l.* as pilot of the Black Deepes, a channel at the mouth of the Thames. His successor as Comptroller, John Osborne, died in 1544, and Robert Legge, a naval captain, filled the vacancy.

Three other officials were appointed in 1545, their titles being "Lieutenant of the Admiralty," "Master of the Ordnance of the King's Ships," and "Surveyor of Ships and Rigging." The first holders were Vice-Admiral Sir Thomas Clere, Admiral Sir William Woodhouse and Captain William Broke. Their salaries were respectively 100*l.*, 100 marks (66*l.* 13*s.* 4*d.*) and 50*l.*, those of the comptroller, treasurer, clerk of the ships, and clerk of the stores, being 50*l.*, 100 marks, 50 marks and 40 marks.

The death of John Wynter, treasurer, in December, 1545, led to changes in the holders of the posts, Broke becoming treasurer, Benjamin Gonson, son of William Gonson, being transferred from clerk to surveyor, Richard Howlett from clerk of stores to clerk of ships, and William, son of John Wynter, becoming clerk of the stores. The titles of the offices, and likewise the salaries, have changed with the passing of the centuries, but all the posts created by Henry VIII for administering his Navy have continued down to the present day, a striking tribute to his foresight. In time of war the Navy officials proceeded to sea in command of ships or fleets, a practice which ensured prompt Admiralty decisions on any points which arose.

Henry soon found that his increasing Navy required dockyards in which its units could be built, rebuilt, refitted and repaired. Previous to the sixteenth century there was no great difference between warships and merchantmen. The latter had to carry guns for protection against the pirates of many nations which infested the seas. The armament was weaker than in warships, but in time of war was readily increased by adding "castles" at the bow and stern and mounting additional guns in them. The developments in warship design at the beginning of the sixteenth century, already referred to, marked a difference in the two types which became more accentuated as the century advanced. The size of warships also increased more rapidly than for merchantmen. These changes caused warship design and construction to become a specialised branch of naval architecture, and the merchant shipyards were utilised to a less extent than formerly. The increased size of warships also necessitated the construction of permanent docks in place of the rough and temporary excavations which had previously been sufficient. Henry proceeded to develop the Royal dockyards.

The two naval ports at the time were London and Portsmouth. Warships of some earlier reigns had been attached to the Tower of London, the centre and scene of many important activities. By Henry VIII's reign this attachment had been broken, and there was nothing yet to take its place. Except in war time only part of the fleet, generally the smaller units, was put into commission and then between April and October. When not employed, the ships were completely dismantled, and lay either at moorings, or in rough docks dug out of the river bank above high water mark, into which they were hauled by capstans, and when in the dock the entrance was dammed and any water remaining pumped out. Payment to 200 men for working capstans when hauling up the Gabriel Royal into a dock at Hamble is recorded in 1528. It was cheaper generally to construct such a dock than to let a ship lie at moorings, for the expenditure on hempen cables then in use—and which were imported from Italy and Dantzic, and very expensive—was large, and the danger to the ship from ice,* often referred to, was obviated. Docking also had the advantage of permitting repair and caulking of the bottom, which was carried out at least every two years. Complete rebuilding was also undertaken in the docks at times. In 1525 many units of the fleet were lying in the Thames and their positions are given in the report of a survey. Two were at or near Erith, one was in a dock at Woolwich, one in a dock at Deptford, two in Barking Creek, one at the Isle of Dogs, two near Redclyffe (Ratcliffe), and five in the pond at Deptford. The remainder were at Portsmouth.

Erith and Deptford were the chief centres of naval activity on the Thames in the early years of Henry's reign. New storehouses, referred to in the patent of Hopton's appointment in 1514, were built at both places, and at Erith the Great Harry was constructed. In 1514 mast-houses were erected at Erith, Deptford and Rainham for the "sure and dry keeping of the king's masts." In 1518 one shed, and in 1520 two more were built at Deptford for "keeping dry the king's ordnance." In 1518 the Kateryn Plesaunce was laid down there and completed in the following year. She was a ship of 100 tons burthen, intended for the king's passage to his fortress of Calais, and the first recorded naval ship built at Deptford. Some items in her cost†

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* Mr. W. Reavell, of Ipswich, at the Shipbuilding and Engineering Exhibition.

† The Great Harry was built to replace the Regent, lost in an engagement in August, 1512, with La Reine, the great carack of Brest. The ships were grappled together during the fight and both destroyed by fire; of 800 English 120 were saved, and of 1,500 French only 20.

* Spert was mainly responsible for the inauguration of Trinity House. He was knighted whilst Comptroller.

* In February, 1517, the Venetian ambassador reported he was unable to proceed to Greenwich by water, as the ice was so very thick.

† In Henry's reign beef was from ½ to ¾*d.* a lb., mutton and veal 1*d.*, and wheat 6*s.* 8*d.* a quarter. A capon cost 5*d.*, a hen 3*d.*, and 400 eggs 4 shillings. Silver was 3 shillings an ounce, copper 14*s.*, and tin 36*s.* 6*d.* per cwt. The victualling allowance of a seaman was 5 shillings a month. In Elizabeth's reign prices increased, and at the beginning of the 17th century were three times those in Henry's time.

were as follows: 80 tons of ballast, 24*s.*; 3 cwt. of tallow, 8*s.*; goat's hair for the boat, 10*d.*; 4 cwt. of resin, 4*s.*; and "to John Baker the younger for lodging 15 carpenters in 5 beds for 3 weeks, 3*s.* 9*d.*" Possibly this was the father or brother of James Baker, Henry's famous shipwright, and father of Matthew Baker, the first master shipwright of the Navy. The places of construction of many of the King's ships are not stated, but there is no doubt Deptford had its share of warship building. It is probable the Galley Subtill was built there in 1541–2. In 1543 the Mydell Shallop, of 70 tons, and the New Galeot, of 140 tons, and in 1546 the Antelope and Hart, each of 300 tons, and the Lyon and Bull, of 200 tons, were built there. Deptford had entered on its career of naval shipbuilding, which lasted until the middle of the nineteenth century. There also the mariners pressed for service in the Navy joined up and were despatched to their ships, and when the fleet was paid off the crews were discharged. It was also a centre of the mercantile marine. Trinity House had its headquarters there, and on the whole Deptford must have been a busy place, especially in time of war.

For some reason which is not recorded in the State Papers, Erith was not developed, but had to give way to its western neighbour, Woolwich. In 1513 the Great Nicholas, bought of John Hopton, was "moored in the Thames against the town of Woolwich," to be refitted and repaired. In 1546 a payment of 46*l.* was made to Sir Edward Boughton for seven years' rent, ending February 21, 1546, of his docks at Woolwich, "which have been occupied in mending the king's ships," and entries for previous years show comparatively large sums paid as wages to shipwrights, caulkers and labourers engaged in preparing naval units for the Scotch and French wars. This was the start of its development as a naval dockyard, and in Elizabeth's reign further progress was made. A great ship, the Elizabeth, of 700 tons, was built there in 1559, and she was followed by many others, including the Prince Royal of James I reign and the Sovereign of the Seas, of Charles I. Deptford remained, however, for well over a century the principal Thames naval yard. A master shipwright was stationed there, who had also charge of Woolwich yard, to which was attached an assistant master shipwright. Generally if a "great" ship was being constructed at Woolwich one of the two master shipwrights attached to Chatham yard superintended its construction. This was the case with the Sovereign of the Seas, which Phineas Pett superintended, with his son Peter Pett as assistant.

(*To be continued.*)

LITERATURE.

The Manufacture of Pulp and Paper: A Textbook of Modern Pulp and Paper Mill Practice. Prepared under the direction of the Joint Executive Committee on Vocational Education, representing the pulp and paper industry of the United States and Canada. Editor, J. NEWELL STEPHENSON. Vol. III. London and New York: McGraw-Hill Book Company, Inc. 1922. [Price 25*s.* net.]

THE Pulp and Paper Associations of Canada and the United States made an important advance when they undertook through their respective educational committees to produce a complete treatise on the principles and practice of pulp and paper manufacture, that should instruct in the particular duties of their calling all who are engaged in the various operations connected with this large industry. Those responsible for the production have taken a wide view of their own duties, as also of the needs of their readers, and several volumes will be required to present the entire story of technical development, with the detail thought necessary. To bring the instruction within reach of all, each volume consists of a number of independent sections, which will be separately circulated, a plan that enables the students to select at small expense those portions in which they are particularly interested. The third volumé only is before us, dealing with the preparation of pulp, and consists of nine sections, the pagination being discontinuous. These sections include the properties and preparation of pulp wood; the manufacture of mechanical, sulphite, soda, and sulphate pulps; the treatment, refining and bleaching of pulp. The scheme should meet with well-deserved success, for the members in breaking new ground are making a serious attempt "to bring an adequate opportunity for education in his vocation within the reach of every one in the industry." It is to be hoped that the audience will be as appreciative as it is large, for unlike older industries in which valuable experience and tradition have accumulated, the pulp industry has no such assistance and support. It is essentially a modern industry of exceedingly rapid growth, for many thousands of workmen are now employed in the technical processes it has created, all of which have matured within the last half-century.

Many authorities have necessarily contributed to the production of this work. In the first section the description of the structural, microscopical, and physical properties of wood has been entrusted to Mr. H. N. Lee, while the editor and Mr. R. W. Hovey deal with its chemical properties. If these subjects seem to be connected only remotely with the main topic of technical manufacture, it might be suggested that the promoters of the scheme, while placing in a prominent position the requirements of the worker, are not unmindful of the interests of the industry as a whole. They recognise that the Empire has been able to hold its prominent position in the great textile industries into which cellulose enters, mainly by the activity of pioneers and the business enterprise of individuals, not by any conscious or co-ordinated movements towards well-defined objectives. Twice within living memory, the paper trade has known two great revolutions, the introduction of esparto and the importation of mechanical pulp, and it is not to be supposed that the sources of raw material are exhausted. That these sources are, and are likely to remain, exotic, further complicates the situation, but in the presence of possible new competitors, it is necessary to grapple with the problems that arise on scientific principles. These problems begin with the selection of the most suitable fibre and improved cultivation, the introduction of more economic methods of working, the possible utilisation of by-products, and embrace a number of other questions, so large that they cannot be adequately discussed even on the ample scale that the committee has adopted.

Mr. S. Roy Turner supplies the section on the preparation of pulp wood, and he traces very clearly, even picturesquely, the course of the wood, coniferous by preference, from the log in the pond or from the raft in the ocean to the grinder room or the chip bin. Very considerable ingenuity is exhibited in the methods of conveying and storing wood, the outcome of long experience, though here opportunities for the introduction of improvements offer themselves to those whose acuteness and energy it is the object of the promoters to awaken and enlist. The losses due to fire and fungus growth necessitate greater precautions than those who handle the "half-stuff" in this country are aware, and call for remedies that promise enormous rewards. The perpetual care displayed and the constant anxiety of those responsible, enable us to see some little way into the actual working life that goes on around a wood mill, and the human interest thus introduced is very welcome.

The more purely technical part of the book begins with the section descriptive of the manufacture of mechanical pulp, or "ground wood," contributed by Mr. H. J. Buncke, who takes up the tale from the arrival of the pulpwood at the grinder room, until it is ground and ready for screening. In this stage of the process, the machinery tolerably simple in design, is planned to separate or disintegrate by mechanical abrasion the simple wood fibres that make up the pulp wood structures, and as in the case of all machinery handling bulky goods of low initial value, the work must be effected with the smallest amount of manual labour and at the minimum possible cost per unit of output. The details of machinery are described and illustrated with great fullness, and these details vary considerably with the policy of mill management, as determined by the quantity and quality desired, and the degree of control of conditions attainable. The skill of the author pilots the student safely through all the mysteries of burrs, of pulp stones, magazine grinders, &c., interesting him in the nice differences of apparatus, till finally a grade of pulp is produced suitable for "news print" or wall paper, or for the many other purposes to which paper is put, for it is a peculiarity of the process that pulp must be treated in the way that best adapts it for its ultimate destination.

But all papers made from ground wood pulp in which the separation of the fibrous and non-fibrous parts is incomplete are liable with the lapse of time to change colour and become brittle and worthless by the action of air and light. Hence have arisen chemical processes of pulp making, which aim, and with considerable success, at dissolving the non-fibrous parts without any great sacrifice of the fibre. Dr. B. Johnsen explains how the method is applied in the sulphite process, where sulphur dioxide gas in water is used as the vehicle for "cooking" the wood. The treatment of the sulphur or of pyrites and the absorption of the gas by limestone, or lime, with the preparation of fortified cooking gas in the digester, into which the wood chips are fed, can be easily followed, the subsequent cooking being effected by introducing steam, which mixes directly with the digester charge. The process was not employed in America on commercial lines till 1885, and by 1920, the united output of the sulphite mills exceeded 2,000,000 tons. When caustic soda, NaOH, is the dissolving chemical, we have, as Mr. A. B. Larchar explains, the so-called soda process, in which the treatment of the chips follows much the same lines as in the case of sulphite pulp. When sufficiently cooked the mixture of pulp and liquor is discharged into a blow pit, and thence into washing tanks, where the pulp is freed from the coloured liquor, which is subsequently treated to recover the soda contained. A third chemical process, producing sulphate, or "Kraft," pulp has for its object the substitution of sodium sulphate (salt cake) for the more expensive soda ash, and the product besides being cheaper has an especially strong fibre. It is a comparatively young industry in America, but seems likely to overshadow the older. Mr. K. M. Thorsen states that the first mill was erected in 1908, with a daily capacity of 25 tons, and twelve years later, it is estimated that the daily production of sulphate pulp in the United States and Canada amounts to 2,500 tons.

Having collected the pulp, whether mechanically or chemically produced, it has to be submitted to various processes of screening, pressing, refining and bleaching, before delivery to the paper mill. The details of these several operations are described with the fullness of detail that characterises the entire work, and exhibit the thoroughness with which the whole has been planned. The illustrations too are quite worthy of the scheme and its manner of fulfilment.

Modern Microscopy: A Handbook for Beginners and Students. By M. J. CROSS and MARTIN J. COLE. With chapters on Special Subjects by various writers. Fifth edition. Revised by HERBERT F. ANGUS. London: Baillière, Tindal and Cox. [Price 10*s.* 6*d.* net.]

THE first edition of this work appeared nearly 30 years ago, and it would be interesting to note the character of the changes and additions that have been made in successive issues, for the continued improvements and enlargements would mark both the progress of scientific development and the demands of the amateur for more thorough and precise information. Treatises devoted to this subject are generally limited to one of two aspects, either the optical theory of the microscope engages exclusive attention, or the method of its use in practical work is alone considered. It is injudicious to attempt to discuss within the limits of a moderate volume, both theory and application. In this instance, however, a combination is effected, and the theory suffers by a reduction to the smallest possible limits. Of course, any attempt at exhaustiveness is disclaimed, but unfortunately, at critical points in the explanation the student will be left in a perplexed position. For instance, with no more information than is supplied here, one would carry away a very imperfect notion of the manner in which an immersion system increases the resolving power of the microscope, and the

reference to spectra without mention of wave length or frequency, further increases the perplexity, when it is found that there is no change of colour in the magnified object. In a phrase that indicates the objects and limitations of the present work, it is stated that it is not possible without instruction—which we presume means the theory of the instrument—"to make the best use of the microscope, and it is only by knowing fully what can be done and how to do it that the worker will be enabled to wrest from his instrument all that it is capable of yielding." We would go further than this, and urge that owing to the complexity of the instrument and the difficulties of its manipulation, the possessor will not be able to use it in an efficient manner unless he has a competent knowledge of the optical principles involved in its construction. Inferior microscopes in the hands of the instructed, will probably do better work and give greater satisfaction than would the choicest examples of the optician's art furnished with the most costly lenses and appliances, when used by an uninformed observer.

The book is divided into three parts. The first is devoted to the description of the arrangement of the general apparatus and contains an inadequate account of the optical principles governing its construction. It is admitted that the due presentation of the remaining sections has compelled the curtailment of the space originally allotted to this part, but it is hoped that the catalogues of the various makers will supply any omissions. This seems a very perfunctory manner of dealing with fundamental matters, and this apology indicates the one fault of the treatise. Among much that is admirable, there has been an attempt to cover too wide a field. The space occupied by the glossary of technical terms and the miscellaneous information concerning microscopic clubs and societies might have been better utilised.

The second part treats of the manner of using a microscope in several departments of science, and written, as it is, by scientists of acknowledged reputation, contains a vast amount of practical information that the beginner will appreciate. The object apparently is to show the modifications introduced in the instrument and its accessories to adapt these for practical research or inquiry in the subjects of medicine, histology, geology, engineering and agriculture. Mr. J. E. Barnard supplements the information on microscopic equipment by describing the forms most suitable for simple demonstration, for diagnostic and research work. The use of the mercury vapour lamp is recommended and rightly, though we doubt if the light is as truly monochromatic as the author represents. Ultra-violet illumination is referred to briefly, but not recommended, since considerable technical experience is necessary for the management of the complex and expensive apparatus. The omission of all mention would have been prudent, where economy of space has to be rigidly considered. Dr. W. E. Cooke continues the tale, and shows some of the results that have followed the application of microscopy to the elucidation of the problems encountered in dealing with sewage, and other factors connected with public health. It is a stimulating chapter, showing that inquiry is inexhaustible and that beneficial results have followed researches that are within the compass of amateur means. Dr. A. H. Drew invites the advanced student to pursue inquiries into the controlling mechanism of tropical diseases, and to trace the development of malaria and of sleeping sickness. The examination of pathological bacteria is, no doubt, a fascinating study, but students of an elementary work will probably find the path strewn with difficulties. Mr. M. J. Cole, whose name appears on the title page, and has devoted many years to practical teaching, gives valuable hints on the preparing, staining, hardening, and mounting of tissues and preparations, which should appeal to the class of students for whom the book is primarily intended. The methods described are suitable and instructive. One may also learn something of the merits and demerits of microtomes and of the process of embedding. The rival advantages of paraffin and celloidin, around which much controversy has raged, are not discussed, but we gather that the author regards paraffin as the quicker but less trustworthy material. The remarks on staining are full and embrace a sufficient number of colouring media whose constituents are described accurately, but the durability of staining is apparently omitted. Both animal sections of tissues, and of stems, leaves, and parts of plants come under consideration as well as fungi, and in whatever department of histology the student is working, he will find here useful information that will be of great service, all the more valuable that the methods have been tested by long experience and have survived the criticisms of many generations of students.

Professor Cheshire caters for the student in geology by describing the optical adjuncts of the petrological miscroscope, and much of the introduction giving illustrations of polarised light might with advantage have been incorporated into the general description of microscope construction. Useful remarks are offered on the adjustment of the instrument, and the author prudently refuses to enter into the subject of crystallography. The metallurgical microscope described by Mr. F. J. Rawlings has few distinctive points, though convenience may indicate variations in detail from ordinary types. The usefulness of the information gained by examination of metal surfaces depends upon the competency and training of the observer, rather than on the instrument employed. The remarks on the necessity and mechanical methods of etching might have been usefully extended. Mr. Ward Cutler carries us back to the activities of bacteria, and invites us to study the comparatively new subject of the employment of the microscope in agriculture, and the evidence it affords of the cause of soil fertility. He has very little to say about the particular form of microscope to be employed, but he emphasizes the necessity of possessing a knowledge of its construction and of the optical principles involved. The space saved is well utilised, for he presents a delightful chapter on soil protozoa and some of the less-known organisms. Much of this chapter is historical, and this feature adds to the interest and affords a pleasant variation.

In the third section the outlook again changes, and we are invited to consider the microscope as a means for creating, or satisfying, the desire to study some branch of natural history as a form of exercise or recreation. It is to those who would quicken their methods of observation, or who take an intelligent interest in the objects around them, that this book is likely to prove of the greatest use. The remarks of Mr. M. Webb are to be welcomed, as they afford an encouragement to intelligent curiosity. He and other capable colleagues describe how and where pond life may be studied, where specimens may be found, collected without injury, and mounted in a way that will ever afford a source of instruction and enjoyment.

BOOKS RECEIVED.

Aeronautical Research Committee. Reports and Memoranda. No. 723: *Aerofoil Theory.* By H. Glauert. [Price 9d. net.] No. 741: *A Graphical Method for the Determination of the Bending Moments and Deflections in an Aeroplane Spar.* By Barbara S. Gough. [Price 4d. net.] No. 771: *Experiments with a Modified Thrustmeter.* By the Aerodynamics Staff of the Royal Aircraft Establishment. [Price 4d. net.] London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office.

United States Bureau of Labour Statistics. Bulletin No. 293: *The Problem of Dust Phthisis in the Granite Stone Industry.* By Frederick L. Hoffman, LL.D. [Price 20 cents.] No. 297: *Wages and Hours of Labor in the Petroleum Industry.* [Price 10 cents.] Washington: Government Printing Office.

The Smokeless City. By E. D. Simon, M.Inst.C.E., M.I.Mech.E., and Marion Fitzgerald. London: Longmans, Green and Co. [Price 1*s.* 6*d.*]

A Review of Trade, Industries and Productions of British South Africa, 1921–22. By C. W. Francis Harrison. Woodchester: Arthurs Press, Limited. [Price 10*s.* 6*d.*]

Ministry of Munitions and Department of Scientific and Industrial Research. Technical Records of Explosives Supply, 1915–1918. No. 7. *Manufacture of Nitric Acid from Nitre and Sulphuric Acid.* London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 11*s.* post free.]

United States Geological Survey. Mineral Resources of the United States. I: 4. *Magnesium in* 1921. By G. F. Loughlin. 1: 5. *Zinc in* 1921. By C. E. Siebenthal and A. Stol. I: 29. *Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in* 1920, *Mines Report.* By C. W. Henderson. II: 2. *Graphite in* 1921. By L. M. Beach. II: 3. *Peat in* 1921. By K. W. Cottrell. II: 4. *Abrasive Materials in* 1921. By L. M. Beach and A. T. Coons. II: 5. *Silica in* 1921. By L. M. Beach. II: 6. *Fuller's Earth in* 1921. By J. Middleton. II: 31. *Sulphur, Pyrites, and Sulphuric Acid in* 1920. By Philip S. Smith. Bulletin No. 730–B. *Erosion and Sedimentation in the Papago Country, Arizona. With a Sketch of the Geology.* By Kirk Bryan. No. 736–A. *The Structure of the Madill-Denison Area, Oklahoma and Texas. With Notes on Oil and Gas Development.* By O. B. Hopkins and Others. Washington: Government Printing Office.

Canada. Department of the Interior. Dominion Water Power Branch. Annual Report 1920–21. *Water Resources* Paper No. 32. *Water Resources Index Inventory Filing System for Recording, Collating and Analysing Water Resources Data.* By J. T. Johnston. Ottawa: F. A. Acland.

"STATIC THEORY AND KINETIC FACT."

To The Editor of Engineering.

Sir,—Your correspondent Mr. H. P. Vowles refers to the fact that capital invested in industrial enterprises is expended upon machinery and other assets, which gradually waste away. This depreciation of capital assets is a universally recognised and inevitable item in the working costs of any industry, and is a charge upon the revenue of the business. Mr. Vowles appears to suggest that this charge ought to be borne by the person supplying the capital.

Let us see how this would work out. To obtain capital for my engineering business I issue 7 per cent. preference shares, and Mr. Vowles subscribes 100*l.* At the end of the first year I write saying that I should be delighted to remit him the 7*l.* interest, but that the small drilling machine which I bought with his 100*l.* depreciates at the rate of 10 per cent. per annum, which depreciation should, of course, be borne by him, so that he owes me a small balance of 3*l.* Will he kindly remit me this sum? or, if he prefers, I will deduct it from his capital, making his shareholding 97*l.* instead of 100*l.* At the end of the second year, he will still have received no interest, and his capital will have shrunk to about 94*l.*; but I think that before "dividend" time had come round again he would have awakened to the realities of the position, and to the fact that it is impossible to obtain capital from any public or private source whatever on such terms.

Stripped of its pseudo-scientific jargon, Mr. Vowles's letter shows that he has not thought out his idea to its logical conclusion. It is mere theorising, uncorrected by reference to practice. Economics is essentially a practical science, and, while it welcomes theory, it has no use whatever for theory which falls to pieces when applied to the touchstone of practicality.

Mr. Vowles quotes Mr. J. M. Keynes as stating that no restoration of the economic position of Europe is possible until a bonfire is made of capitalist claims. When through bad management, unfavourable circumstances, or a great catastrophe, a business can no longer be carried on, the shareholders have to make the best of a bad bargain, and sacrifice all or part of their capital; but no one would suggest that an industry would be able to obtain any capital at all if that capital had to be subscribed on Mr. Vowles's "kinetic" principle and were foredoomed to waste away. No State, no public body, and no private individual could afford to furnish capital on such terms, and all industry would come to a standstill.

Mr. Vowles may be right when he says that "man is still far from being a reasoning animal," but I fear that such reasoning as is contained in his letter will scarcely help mankind to a better state.

Yours faithfully,
E. H. Dance.

22, Park Parade, Whitley Bay,
July 31, 1922.

The Brazilian Centenary Exhibition.—In connection with the forthcoming Brazilian Centenary Exhibition which opens at Rio de Janeiro in the autumn, Messrs. Vickers, Limited, have arranged to show a number of their cinematograph films illustrating various branches of engineering in which the firm is engaged. The films have all been produced by the firm's own photographic staff, and prior to being sent out an opportunity was recently afforded for seeing them at the projection theatre at Vickers House. The titles of the films being sent out are in Portuguese to meet the needs of the audiences likely to see them at Rio. The full set is divided into seven sections, of which the first and second deal with scenes in the River Don Works, Sheffield. The third depicts scenes in the Naval Construction Works, Barrow-in-Furness, and shows various incidents connected with the building and launching of a battleship, submarine, floating dock, &c. The fourth is devoted to the same works, but deals with airships, while the fifth is concerned with machine guns, howitzers and other ordnance up to 15-in. naval guns. The two last sections are devoted to aviation, one dealing more particularly with the Vimy commerical aeroplanes built at the Vickers' Weybridge Works, and the other with the Vickers' "Viking" amphibiand aeroplane. The choice shown in the selection of incidents filmed is excellent and the exhibition in Brazil will doubtless prove attractive, and we hope also of commercial value.

EFFICIENCY OF STEAM-PIPE COVERINGS AT HIGH TEMPERATURES.

THE apparatus for determining the efficiency of steam-pipe coverings, which we illustrate in Figs. 1 and 2, on the present page, was designed by Mr. C. Jakeman, of the National Physical Laboratory, and constructed there. It is intended especially for high temperature work. The apparatus which Mr. Jakeman previously employed for testing nearly every make of covering in use was limited to testing up to a maximum temperature of 450 deg. F. corresponding to saturated steam at 350 lb. per square inch. The essential dimensions of the old apparatus have been adhered to in the new design, so as to make the test results comparable; but the new apparatus involves several interesting novel features, both in the general arrangement and in the details of the heating coils adopted to secure uniform heating. The covering under test is put on a mild steel pipe, 4 in. internal diameter; the pipe ends are closed by blind plate flanges bolted on. The radiation from these blank ends must be allowed for, and this correction is obtained by dividing the experimental pipe into two sections of unequal length, but otherwise similar, so that those losses can be eliminated by difference. The one pipe as actually employed has a length of 13¾ ft.; the other pipe, facing it, is only 2 ft. long. When the heats lost by the two pipes at any particular temperature are determined, the difference between the two heat values represents the loss of heat in a pipe of the differential length, 11¾ ft.

Fig. 1.

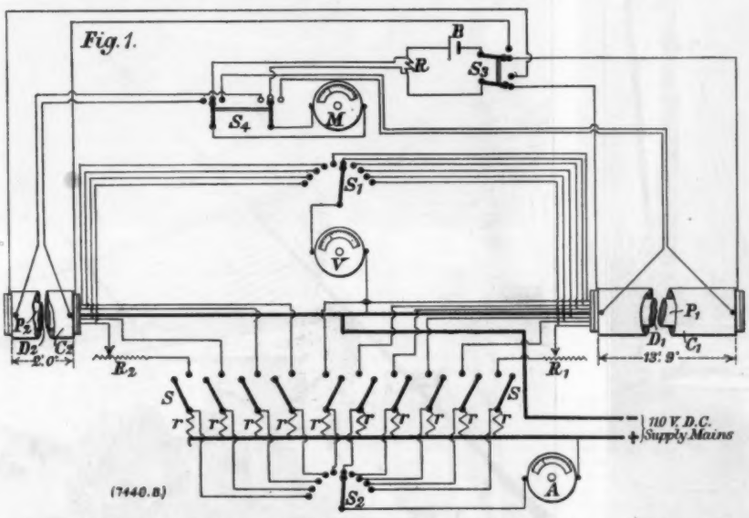


Fig. 1 illustrates the general arrangement and the connections to the heaters. The covering under test C_1 is on the long pipe P_1 (on the right-hand side) which is fitted with the heater D_1. P_2 is the short pipe. The electric heater (Fig. 2), placed inside the long pipe, consists of a number of straight lengths of chromi wire of such a size that four complete lengths of the long pipe can be shunted across the mains without any undue flow of current. The wires H are arranged in six concentric rings, each controlled by a separate switch. The heat supply is thus uniform about the pipe axis, however many of the circuits are in use. These rings contain 8, 12, 16, 20, 24 and 28 wires, and each group of four wires is paralleled together by connections at the end; the unit of four wires takes 7 amperes at 108 volts, which totals up to 189 amperes or rather more than 20 kw. when all the wires are in use, to raise the temperature of the bare pipe to 1,000 deg. F. When the pipe is fitted with a good-quality covering, the heat energy ranges from ¼ to $\frac{1}{15}$ of this amount (required by the bare pipe), but it is necessary to provide sufficient energy for the test of the bare pipe, since the heat loss from the covered pipe is compared to that value. The shorter pipe is provided with a similar heater, controlled by four switches. For fine adjustments a sliding resistance is used in series with one of the circuits.

The discs of uralite, A B C, spaced about 3 in. apart, through which the heater wires are carried, were not found to be good insulators as originally supplied, but the material became perfectly satisfactory after being heated to 700 or 800 deg. F. The negative ends of the units are brazed to a copper disc D which covers the uralite disc B at the end of the pipe and is connected to a copper rod E brought from the disc through the end cover, which is insulated by means of a silica sleeve and mica washers. Holes are provided in the copper discs to allow the positive ends of the units to pass through with plenty of clearance. On another uralite disc C six copper rings F, to which the positive ends are brazed, are mounted to serve as positive terminals. From each of these rings a copper rod G passes through the cover. Every alternate wire is bent over on the disc A and passed through the next hole in the same disc. The result of this arrangement is that four lengths of wire are in series between a joint in the negative and a joint in the positive collectors. Fig. 2 shows the end view of the heater uralite discs, the negative plate and the positive rings, and an axial section of the end discs. The uralite discs are broken away in four places to allow the air to diffuse past the discs.

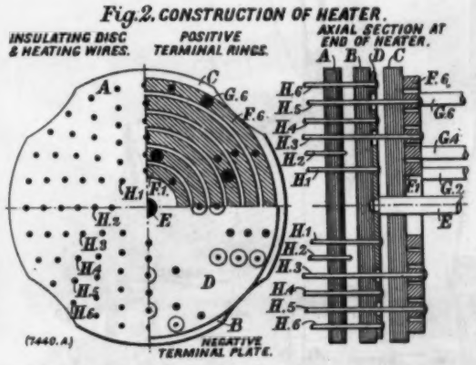
Seven connections in the case of the long pipe and five in the case of the short pipe are all that are required to pass through the cover of the pipe. Six switches S control the current to the six divisions of the heater in the former case, four switches in the latter. Each switch is connected through a shunt r, and every shunt can be connected to the ampere meter A by means of a multi-pole switch S_2 which is constructed so as to introduce little extra resistance into the circuit. The drop in volts in each heating unit is measured by the voltmeter V and the selector switch S_1. The other parts of the circuit shown in Fig. 1 are for the measurement of the actual temperature of the pipe. This measurement is deduced from the electric resistance of the pipe itself. A cell B of 2 volts, connected to a shunt R and a double-pole switch S_3, sends a small current through each pipe in turn. The current enters through the flange so as to keep the current-flow through the pipe uniform. A switch S_4 joins the millivoltmeter M in turn to the shunt R or to two connections screwed into the ends of the two pipes. The ratio of the reading obtained on the pipe to that obtained on the shunt, multiplied by the known resistance of the shunt, gives the resistance of the pipe and thus a measure of its temperature.

The calibration of the apparatus has been carried out by two methods. In the first method a long platinum wire was supported inside the pipe, near the wall, to serve as a platinum resistance thermometer. In the other method a number of thermo-junctions were soldered into fine holes drilled on the outside of the pipe wall and the mean reading of these was taken as the mean temperature of the pipe. The two methods agreed closely, and were further in good agreement with the calibration calculated from the area of the pipe and from the specific resistance of mild steel.

Further to explain the method of allowing for the end correction, let us assume that the temperature in the middle of the long pipe will be t_1, that the flanges with end covers have the lower temperature t_2, and that the temperature on intermediate lengths varies between t_1 and t_2. If we now supply heat to the short pipe until the flanges with end covers are also at temperature t_2, we shall there likewise have portions exceeding t_2, and, if the short pipe be long enough, also a small portion in the middle at t_1. Under these circumstances, the parts on the two pipes at varying temperatures will be of the same lengths, since the conditions for the establishment of the heat gradient are the same. Hence, the difference in the energy supplied to the two pipes will give the heat lost by a pipe without flanges of a length equal to the difference in the lengths of the pipes. The experimental condition required is, therefore, that the temperature t_2 of the flanges and end covers be the same in the two pipes, and that the temperature of the middle portion of the long pipe be observed. It must be noted that, if the short pipe be not of sufficient length, the temperature t_1 will not be reached at the middle of the pipe; in that case, the correction will be too small, and the efficiency deduced will be too low. The corrections may, however, be subject to very considerable error without greatly influencing the value of the result. The net loss from the bare pipe is about five times the value of the correcting loss, so that an error of 10 per cent. in the correction will cause an error of 2 per cent. in the heat loss, and with a covering of an efficiency of about 90 per cent., that would cause an efficiency error of 0·2 per cent.

The time required for a test depends upon the efficiency of the covering, since it takes a considerable time to reach a state of thermal equilibrium when the conductivity of the covering is small. After drying the covering for 24 or 48 hours, the temperature is adjusted to the desired value, and observations are taken, late in the afternoon, of the temperatures and the energy supply. The current is then left on over night, and the observations are repeated the following morning. If these figures agree with the previous set, the energy is slightly reduced, until a new condition of thermal equilibrium is reached by the afternoon. The energy supply is kept on during the night, and new readings are taken the following morning; these will, in general, be in accord with those of the preceding afternoon. Thus, observations are obtained at temperatures differing by about 40 deg. F., and from these figures the mean efficiency over that temperature range can be deduced. The whole test will take 3 or 4 days.

Fig. 2. CONSTRUCTION OF HEATER.



The following data were obtained in testing an asbestos covering of very good quality:—

Mean temperature of pipe	804 deg. F.	
" " air	68	"
Mean difference of temperature	736	"
Energy supplied to long pipe	1,216 watts.	
" " short pipe	222	"
Net energy required by the test length of pipe	994	"

The net energy required for the bare pipe having been found, in previous tests, to be 13,240 watts, the efficiency of the cover is $\frac{13,240-994}{13,240} = 92{\cdot}5$ per cent.

THE BIRMINGHAM EXCHANGE.—The directory for the present year of members, subscribers and representatives who form part of the Birmingham Exchange, has come to hand. It is published by authority of the Committee, and its price is 2*s.* 6*d.*

IRON AND STEEL INSTITUTE.—The autumn meeting of the Institute will be held in the Museum Theatre, York, on Tuesday and Wednesday, September 5 and 6. The following is the list of papers which it is expected will be submitted at the meeting: "The Changes of Volume of Steels During Heat Treatment" (1, Air Hardening Nickel Chromium Steels), by L. Aitchison; "Nitrogenisation of Iron and Steel by Sodium Nitrate," by L. E. Benson; "A Brinell Machine Attachment for Use with Small Specimens," by E. D. Campbell; "A Preliminary Magnetic Study of Some Heat-treated Carbon Steels," by E. D. Campbell and — Johnson; "Some Experiments on the Flow of Steels at a Low Red Heat, with a Note on the Scaling of Heated Steels," by J. H. S. Dickenson; "An Investigation on the Factors Influencing the Grain and Bond in Moulding Sands," by C. W. H. Holmes; "Practical Notes on the Manufacture and Treatment of High-speed Steel," by H. K. Ogilvie; "The Bases of Modern Blast Furnace Practice," by A. K. Reese; "Reversing Cogging Mills: their Drives and Auxiliary Equipment," by G. A. V. Russell; "The Diminution of Lag at Ar. 1 through Deformation," by J. H. Whiteley. Visits to works and other places of interest are being arranged.

METHODS OF STOWING LIFEBOATS ON SEA-GOING VESSELS.*

By A. Welin, C.B.E.

Some nine years ago a great maritime disaster evoked a popular clamour to the effect that lifeboats should in future be carried by passenger vessels in sufficient numbers to accommodate all persons on board. At that time, few, if any, anticipated difficulty in giving effect to this policy; any doubts, therefore, as to the practicability of such a considerable provision were immediately silenced, and owners found themselves confronted with only two alternatives, viz., to find the requisite accommodation to satisfy the popular outcry, or to reduce the number of passengers carried.

Thus it happened that long before the International Convention for the Safety of Life at Sea (constituted on the initiative of the British Government) had completed its deliberations, several of the principal shipping companies were advertising that the steamers of their various fleets were equipped with "boats for all." While this statement was no doubt true in substance, closer examination soon brought to light the fact that, in a umber of cases, the widely advocated "boats for all" were, when it came to the point, situated in such impossible positions, as not only to be of very questionable value as a means of saving life in case of disaster, but possibly even to constitute a positive and additional danger.

Boats of every type, often in a totally unseaworthy condition, were hurried into commission to meet the unprecedented demand, indeed it was no infrequent occurrence to see lifeboats lowered from incoming liners, towed hurriedly to some outgoing steamer, and lifted on board and deposited anywhere, to make up the inevitable shortage. Worse even than this was the fact that no means for launching these boats were provided, so that in the majority of cases they constituted simply an additional and highly undesirable amount of top hamper. Thus it followed naturally that the committee of experts appointed by the British Board of Trade to advise as to the most efficient manner in which the ultimate findings of the International Convention might be carried into practical effect, found itself confronted with problems of a totally anomalous and most embarrassing nature. Even to-day, in spite of a vast amount of earnest research and experiment, with numerous inventions having for their object the solution of these difficult points, there yet remains, to a lamentable degree, an obvious inefficiency in many a modern boat installation.

Where the total number of persons carried by any vessel under her certificate does not exceed the seating accommodation provided by a single row of lifeboats on each side of the vessel, each boat being handled by an individual set of davits, the problem does not present any difficulty. In the vast majority of cases, however, such ideal conditions do not and cannot exist, and then various complications arise. One is driven to choose between the various methods of nesting, double-tiering, double-banking, or transporting the boats, or to evolve some combination of one or more of these methods, and seeing that each system possesses certain peculiar disadvantages as well as advantages, the final selection is far from being easy. The special object of this paper is not to advocate any one of these methods at the expense of another, but rather to point out such limitations and advantages as may be inherent to each. The amount of space available, the position, number and bulk of deck encumbrances, &c., vary so much on different vessels, that only by a close and genuine study of each individual case can the highest possible degree of efficiency be ensured, without, at the same time, hampering the working of the ship, or unduly increasing its top weight.

Among the many suggestions embodied in the findings of the International Convention, the "stacking" of so-called decked, or semi-collapsible, boats was prominent, and was at the time regarded by many as pointing the way to the practical solution of the admitted difficulties. Before long, however, it became apparent that, generally speaking, this class of boat required even greater care than the ordinary open lifeboat, and that unless readily accessible and frequently overhauled, they were subject to much more rapid deterioration. Thus, such boats, with one or two possible exceptions, came increasingly into disfavour with those responsible for their continual heavy upkeep, not to mention their periodical entire replacement, so much so that to-day only a relatively small number of these boats is included in the life-saving equipment of a modern liner. Nevertheless, it must, be admitted that the trouble complained of was, in a number of instances, due rather to the impracticable way in which these boats were often stowed, than to any inherent worthlessness of the boats themselves. A thoroughly workable installation of such boats and one which is still in good working order, after many years of service on the poop deck of the R.M.S. Aquitania, is shown in Fig. 1, page 146, but in this case, the stowage arrangement was designed in such a way that each individual boat can, at any time, at sea or in port, be lifted out of its chocks, opened up, inspected, and such repairs and/or painting effected, as may be required. To this general principle of accessibility must be attributed the considerable measure of success with which this arrangement has worked. In this instance inboard or "feeding" davits are provided, which are clearly shown in the illustration. These davits are provided with a special differential chain tackle, which is, in its turn, attached to a wire compensating span, so as to ensure the boats travelling on what is practically a horizontal path. By this means, the inboard boats may be passed from either side of the deck to the other, and all lowered away from one side by the "lowering," or davits proper.

Fig. 2 illustrates a more recent, but nevertheless far less satisfactory athwartship installation of boats. In this case, the boats are of the "nested" type, which are in themselves more substantial than those above referred to. The unsatisfactory feature of this arrangement, however, is to be found in the fact that no means whatsoever have been provided for the inside groups to be lifted or traversed from their position; on the contrary, after the outboard boats at the extreme ends of the row have been launched, the inboard nests have to be labouriously man-handled and manœuvred into position for attachment to the davits. Even in harbour, time seldom permits of this operation being satisfactorily effected, and there is consequently, reason to fear that these inboard nests of boats may possibly be left without adequate attention. A final and still more unsatisfactory aspect of this arrangement presents itself when one considers what would be likely to happen in an emergency, either with the vessel rolling, or stationary, but listed heavily to one side or the other.

In this connection, one may perhaps be permitted to question, from a strictly life-saving point of view, the wisdom of too wide an adoption of nested boats. It must always be borne in mind that with one exception referred to later, the small boat must be unnested and put into the water first, and it therefore follows naturally and unavoidably that the larger and more serviceable boat is the last to reach the water; precisely in fact, the reverse of what it should be. Moreover, should there be, in the case of emergency, insufficient time to launch boats nested inboard (even if adequate means for traversing or transporting these boats be provided) it seems improbable that such boats could be counted upon to float off a sinking vessel, and thus fulfil their functions as life-savers. Since the carrying capacity of the lower boat would already be materially reduced by the weight of the boat nested in it; it would seem equally improbable that the "de-nesting" process could happen automatically during the "floating off" process, if such occurred. Undoubtedly, therefore, the particular installation illustrated in Fig. 2, page 146, would have gained in efficiency had a single row of open lifeboats of the standard type been substituted for the immobile inboard nests, with the addition of some proper means for traversing them from side to side of the vessel. Any resulting deficiency in cubic capacity could have been made up by rafts in the absence of another and better solution.

Fig. 3 illustrates an approved type of transporting or traversing gear, which will allow an inboard boat to be brought under a single-acting pair of davits ready for lowering, or, according to the length of chain and rails used, will permit of the boat being traversed across the full width of the ship, the operating mechanism being sufficiently strong to traverse a full-sized boat up the deck against a list of at least 7 deg. as is required by the regulations. A slight modification of the trolley renders it equally suitable for collapsible boats. The trolley is provided with two sets of arms (or levers)

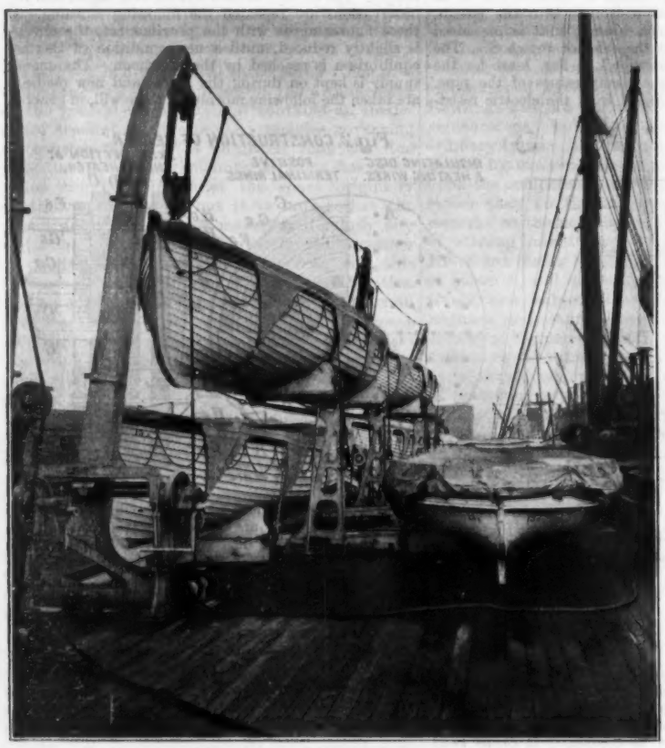


Fig. 5. Superimposed Boat Installation with Double-Acting Davits.

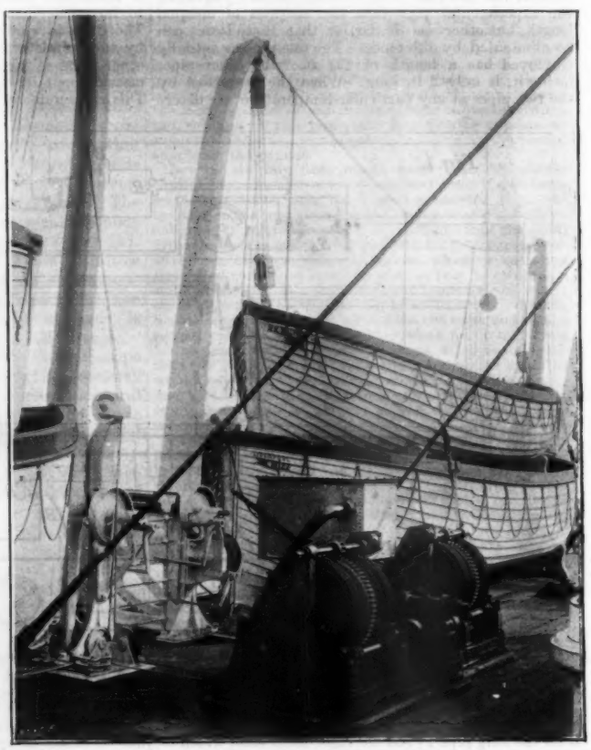


Fig. 6. Boat Installation with Wire Falls; S.S. "Olympic."

* Abstract of Lecture delivered to the Japanese Institute of Naval Architects, Tokio.

which, when folded down, allow of its being travelled underneath the keel of the boats. The tackles provided at the long ends of the arms are then hove on, and the arms rising, lift the boat out of its permanent chocks sufficiently to enable these to be folded down flat on deck, as may be seen in Fig. 3, leaving the boat free to be traversed in either direction. The arrangement of the operating standard and chain drive is clearly seen in the figure, and requires no further description. The advantages of this particular method of transporting, or traversing, boats are principally connected with questions of cost and weight, otherwise "feeding" davits of the type above described, especially when used in conjunction with double-acting davits, are undoubtedly superior, for not only may several boats be in process of being fed across the deck at one and the same time, but the whole of the gear is much more easily accessible than is the case with traversing gear. A great variety of combinations is rendered possible by the adoption of "feeding" davits, combinations by which, in more than one instance, quite extraordinary difficulties have been satisfactorily surmounted.

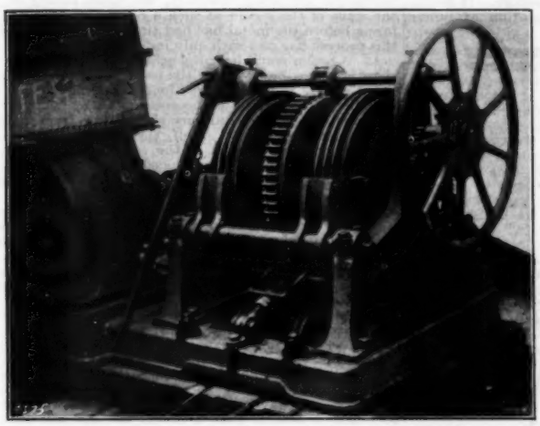


FIG. 7. CONTROL GEAR FOR BOATS ON THE S.S. "OLYMPIC."

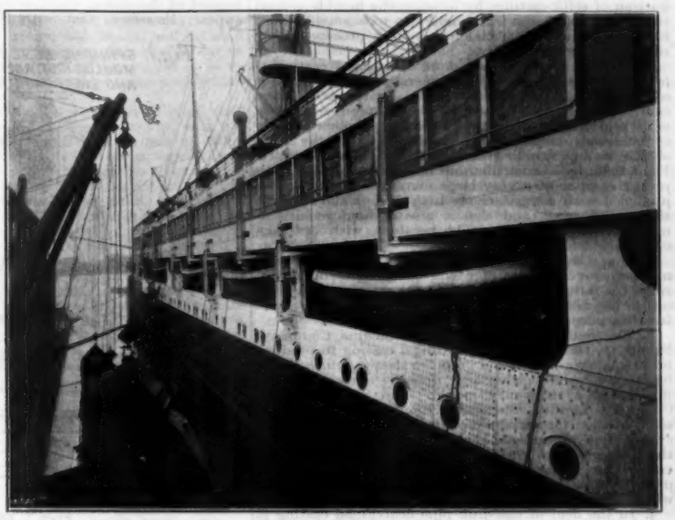


FIG. 8. ARRANGEMENT OF BOATS ON THE S.S. "BERENGARIA."

An efficient method of manipulating nested boats is that of providing each individual boat with its own set of blocks and tackle, so that both boats may be swung out simultaneously into the lowering position. Such an arrangement, however, is only applicable on board vessels where there is an open deck below the boat deck proper, in which case the larger boat is lowered to the level of that deck, and the passengers embarked therefrom. Moreover, it is extremely necessary to guard against the serious danger of the upper boat being accidentally lowered before the lower one has got clear of the ship's side, and this particular arrangement is only sanctioned by the authorities subject to the provision of some form of "fool-proof" bollard, arranged so as to prevent the inner boat from being lowered until the falls of the first boat have been cast off. The first installations of this kind have been installed on a vessel at a Clyde shipbuilding yard, and Fig. 4 illustrates the arrangement. In view, however, of the present lack of positive experience with the arrangement shown, it is open to question whether a still further development of this system will not make for additional safety. For this purpose the falls of the upper and inner boat are kept free of the bollard altogether until the moment for lowering, and this bollard being of the standard simple form, obviously cannot be used for both sets of falls at the same time. Moreover, by means of a simple safety device, the blocks of the inner boat are positively locked until the bollard is available, which cannot be the case until the first boat is well away. The steel wire compensating arrangement employed in this case is also of interest.

The advantages derived from these methods of manipulation are, the elimination of unnesting winches, the fact that the lower and more commodious boat is launched first instead of last, and, finally, that the rounding up of tackles and the otherwise unavoidable repetition of the movements of the davit arms are all obviated. On the other hand, the gears having to sustain the weight of both boats simultaneously, necessarily become heavy (in this case, for instance, the static test load of the davits was 15 tons per arm) and their cost is proportionately increased. While the system of "nesting" boats as above described will probably continue to find many warm supporters, it would seem certain that at least an equal number would prefer to see standard open lifeboats of equal dimensions superimposed one upon the other. An installation of this kind is illustrated in Fig. 5. The authorities do not favour the chocking of one boat directly upon another, and this objection is met by the fact that the upper boat in this case is chocked and securely gripped to a pair of light steel frames, and is entirely independent of the boat immediately beneath it. The latter is supported by the usual type of "push away" chocks, and may be lifted, overhauled or swung out, loaded and launched, without in any way disturbing the one chocked above it. Where additional boats are carried inboard of the others, double-acting davits, such as those shown in the illustration, are used, and the steel frames, or pedestals, are hinged so as to fold down flat on deck, thus permitting the passage over them of the inboard boat. It will be appreciated that such arrangements make it possible, to give adequate attention to the upkeep of all the boats with the minimum of trouble. In the long run, therefore, even on the assumption that the original cost be comparatively high, an installation of this nature should prove to be an economical one. The only objection to the system overheard by the author was that it would detrimentally affect the appearance of an otherwise smart-looking ship, but such a fear would seem to be groundless.

In most of the installations described in the foregoing, ordinary manilla falls are employed, and these are paid out in the usual manner from cruciform bollards of a type now almost universally in vogue. For vessels having a very considerable freeboard, however, with the boat deck 70 ft. or, perhaps, even 80 ft., above the water line, wire falls are undoubtedly preferable, and installations similar to that shown in Fig. 6 are being largely adopted. This installation is that of the Olympic, and gives a good idea of the way in which the wire falls are rove, and of the general arrangement of the "controls," by which the lowering and hoisting of the boat is effected. The undesirable complication arising from the use of clutches is entirely avoided, for the drums of these controls are themselves mounted on eccentric bearings, and can thus be thrown in or out of gear, or braked, as in the illustration, by the simple movement of a hand-lever, or by a slight turn of a hand-wheel shown in Fig. 7, which illustrates the latest development of this control. The unit shown comprises a 30-h.p. watertight electric motor mounted between two controls, on a common baseplate. The motor is required for hoisting only. For launching the boats, no current is required, the drums being simply eased out of the specially adjusted brakes. The whole operation is under absolute control, and is carried out from beginning to end by hand. This is a feature of vital importance, and one strictly insisted upon by the authorities. On the right hand davit frame shown in Fig. 6, a small drum, divided by a centre flange, will be observed. The standing part of the falls from both davits, instead of being made fast to a becket on the top block, are brought back and permanently secured to this "adjuster," with a few turns of each laid on in opposite directions. The object of this adjuster, as will readily be gathered, is to effect the trimming of the boat without actually lifting it, should the falls have coiled up unequally on the control drums, as is almost inevitable. It also enables the boats to be launched in a horizontal position even if the ship should be badly down by the head or stern, thus forming an indispensable detail of the system. While this installation and others of a similar nature have proved eminently successful, it goes without saying that they require a good deal of attention, and unless those responsible for the ship are prepared to detail qualified men for this definite purpose, it would seem wiser to adhere to some simpler form of launching gear.

The remaining illustration, Fig. 8, shows a unique arrangement, which has, so far, only been applied to three vessels of exceptionally large tonnage; the vessel illustrated is the Berengaria. At the forward end of the top deck, units of superimposed boats handled by control gears, of the kind described above, are installed, but the remaining boats have been removed to the lowest open deck of the ship, where they are housed in bays. The forward davits in each bay are suspended from above, in order to allow the boat a free passage underneath; the actuating mechanism is attached to the after davit, and motion communicated to the forward davit by means of a coupling rod, normally lying close against the curtained plate of the deck above, and insuring the simultaneous swinging out of the two davits. Wire falls and controls are used throughout, the adjusters being fixed to the deck-house wall at a convenient height. This method of installation has not unnaturally evoked a considerable amount of discussion, but from such discussion there emerges only one positive disadvantage, viz., that the boats on the lower deck interfere with the light to the cabins behind them. On the other hand, that there are concrete advantages to be gained by the adoption of this system is undeniable. The removal of a considerable amount of top hamper, some 20 ft. lower down, is in itself a point of sufficient importance to compel consideration both as regards stability, rapidity of operation and the reclamation of deck space where such is of the greatest value. With this arrangement, moreover, the marshalling of passengers to their respective boats in case of disaster, should be greatly facilitated.

In conclusion, one would be inclined to emphasise the fact that the points most earnestly to be considered by shipowners must always be to avoid, as far as possible, costly repairs and replacements both of the boats themselves and of the means for handling them, by providing an installation so arranged as to render frequent and proper inspection a far more simple matter than has often been the case in past years, and to make such dispositions with the full realisation that not only may it be more economical in the long run to incur a slightly greater initial cost, but that such a policy must most assuredly make for a far greater efficiency from a life-saving point of view than would otherwise be the case.

THE INSTITUTION OF ENGINEERS (INDIA).—We have received volume II., for April last, of the proceedings of this Institution, whose home is in Calcutta. The papers it deals with are entitled "Some Engineering Aspects of Geology," "Hydro-Electric Power in Mysore," "Water Supply of Bengal Towns," "Organisation of Ordnance Factories in Peace for War," "Sub-Soil Percolation," "Flood Absorption in Tanks," and the Presidential Address by Major G. H. Willis. The Institution is among the youngest, and the fact that in its second volume of proceedings it has brought together the valuable set of papers whose titles are given above augurs well for its future.

LIGNITE TAR DISTILLATION.—Lignite tars are profitably distilled at reduced pressure, in order to save time and fuel, and to reduce the tendency of the tar to crack. In Germany, it was formerly customary to start the distillation with a pressure 10 cm. (4 in.) of mercury below atmospheric, and to finish the process at a pressure deficiency of 40 cm. (16 in.). When, during the war, the demand for fuel oils and producer tar from lignite increased, attempts were made to work with higher vacua, while at the same time the capacity of the still was enlarged. Of the various processes introduced, only those of the Deutsche Erdöl A.G., of Rositz, seem to have survived, the plants being supplied by the Brünn-Königsfeld engineering works, which specialise in this field. In one of these plants, described by Dr. E. Graefe, in *Brennstoff-Chemie*, of June 1, the pressure reduction is carried to 68 cm. (27 in.), and there are eight boilers or continuous stills, each of 40 cub. m. (1,400 cub. ft.) capacity. The stills resemble horizontal Cornish boilers. They are arranged in series and slightly in cascade, so that the liquid flows from one still into the other. The vapours from each boiler pass into a dephlegmator, which is placed inside the preheater of the respective boiler, so that distillation begins in the dephlegmator, which is coupled to its own condenser; 16 separate fractions of the distillate may be drawn from the stills and condensers. The still temperatures range from 200 deg. C. to 320 deg. C. The final distillation to coking takes place in special cast-iron stills. One of the advantages claimed for the process is that good lubricating oils and paraffins are obtained.

CENTRIFUGAL CASTING.*

By Leon Cammen, New York, N. Y.

Centrifugal castings of metals is an old art, but it did not assume commercial importance until the last decade. Since then, however, while it has not attracted much public notice, its progress has been very rapid. It has already become an important factor in such industries as the manufacture of paper-mill rolls and railroad car wheels. It is to-day the most vital problem before the makers of cast-iron pipe in the United States, and, with the most recent developments, promises to revolutionise the two most profitable lines of the great steel industry, *i.e.*, tubular goods and plate manufacture. In the present paper it is intended to describe the process of centrifugal casting of hollow metal objects. The field of centrifugal casting is, however, far more extensive. This process has been successfully applied in the production of non-metallic tubes, such as concrete pipe (Hume process and others). It has also been used for the production of solid castings by locating the moulds around the rim of a spinning wheel, and also to a small extent for the production of solid ingots by a process largely similar to the above.

2. The field of application of centrifugal casting is far more extensive than is generally realised and is already worked on a large scale. In the first place, centrifugal casting is a cheap method of producing goods of certain shapes, namely, those having a hollow interior symmetrical about an axis passing through the body of the casting, whether concentrically or eccentrically. The advantage of such methods lies in the fact that with proper equipment a very large number of units can be produced with comparatively little labour and without the use of cores, and that a greater homogeneity of metal is secured than could be done with ordinary casting.

During the war several concerns employed this method, for example, for the production of piston rings for automobile engines, and even now establishments like the Ford Motor Company continue to use it for that purpose.

3. The Sandusky Foundry and Machine Company, Sandusky, Ohio, employs centrifugal casting to produce bronze paper-mill rolls and propeller sleeves, which would be much more expensive and probably less satisfactory if cast in a stationary mould. The Stokes Casting Company, Limited, Mansfield, England, has used the same method for making cast-iron liners for aluminium cylinders of internal-combustion engines of such a small thickness and high grade of metal as could not be duplicated by any other process except machining, and at a price only a small fraction of what a machined tube would have cost.

4. In the field of cast-iron pipe centrifugal casting is in a fair way to displace sand-moulded pipe entirely. The method of centrifugal casting of cast-iron pipe has been primarily developed by a Brazilian engineer, Dimitri Sensaud de Lavaud, and has been extensively employed in England, Canada and Japan. Some months ago the United States Cast Iron Pipe and Foundry Company, of Burlington, N.J., one of the largest manufacturers of cast-iron pipe in the world, acquired the De Lavaud patents for America and are going into the manufacture of centrifugally cast cast-iron pipe on a large scale. It is stated that they can make 600 lengths a day with 25 men and the centrifugal process, as against 400 lengths with 80 men by sand moulding, in addition to which centrifugally cast pipe is roughly 15 per cent. stronger than sand-cast.

5. Another development in centrifugal casting which has already become of commercial importance is the manufacture of railroad wheels as carried on, for example, in this country by the American Steel Foundries. The idea itself is not new and there are English patents describing it dating back to the early sixties. In 1882, Webb, speaking before the Iron and Steel Institute† stated that at the works at Crewe he was casting steel wheels and making them sound by casting them on turntables. This was, however, a fairly crude process applicable only of plain steel. As cast centrifugally by the American Steel Foundries, the wheel has a manganese-steel rim and a soft-steel hub and spokes, the depth of penetration to manganese in the rim being regulated at will. Considering the difficulty of casting such an article as a wheel without rupturing it during cooling, the development is of great engineering interest.

6. Of late, centrifugal casting has acquired a further importance in the development of a method by which tubes and hollow billets may be successfully cast of such metals as monel metal and alloy steels, which can neither be cast into thin-walled tubes nor pierced by the ordinary methods. Recent developments in the art are such as to open really great possibilities for the future, a matter which will be discussed in a later part of this paper.

7. The art of centrifugal casting of hollow metal objects is quite old and has been practised on a commercial scale since the beginning of the last century. The earliest English patent (Eckert) dates as far back as 1809, and the earliest American patent to Lovegrove was issued in 1848. At about the same time Andrew Shanks, in London, England, began to make cast-iron pipe 12 ft. long and 3 in. in diameter by pouring molten metal into a spinning wrought-iron mould. His process was described in America in the *Scientific American* of December 1, 1849, and it is of interest to note that in its basic features of design the Shanks machine does not differ in any way from the great majority of machines working with a cold mould at the present day.

8. Attempts were made at an early date to apply centrifugal casting to ingot making with the view to improving the quality of the metal and, for example, M. Tresca, in a paper before the Institution of Mechanical Engineers,* states that the most remarkable instance that he had met with of freedom from air bubbles was in the case of a Bessemer rail manufactured at the Imphy Iron Works near Nevers in the Department of Niévre; and he had ascertained that the method adopted at these works was to pour the molten metal into a revolving vessel driven at a considerable speed so as to clear the steel of air by rapid rotation. This method proved very effective in practice in freeing the steel from the minute air bubbles which it contained on leaving the converting vessel or the melting pot.

9. A survey of the literature and of the numerous patents issued on centrifugal casting in this country and in Europe would indicate that practically all the essential features were covered by patents issued prior to the beginning of the twentieth century, with the exception, however, of those dealing with the temperature control of the metal, which is a new feature. It would appear, therefore, that with the exception of minor details and one or two features in special casting processes, there is no reason why any good engineer could not design and operate a successful casting machine with a non-heated or non-cooled mould without running into legal complications. At the same time, it might be well to realise that the very fact that the basic features of the general process are already free makes those who have developed some of the few minor features particularly anxious to protect their patent rights in them. Because of this, a general familiarity with the patent situation is desirable to avoid involuntary infringement by using some minor detail such as, for instance, a particular type of pouring spout that has been covered by a patent. It is to assist in this that an appendix to the paper (not reproduced.—Ed. E.) has been prepared, giving as far as the author is aware, a complete list of all patents on centrifugal casting issued since 1848 by the United States Patent Office and prepared after a careful investigation of the entire field. Another Appendix deals with bibliography.

Fig.1. SPINNING BENCH FOR REMOVABLE MOULDS (SUITABLE ONLY FOR SHORT AND LIGHT MOULDS.)

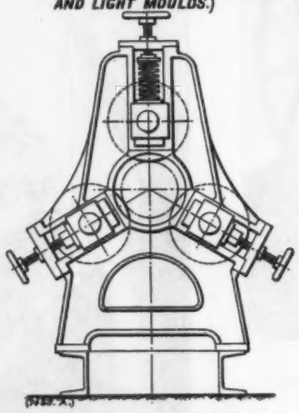


Fig.2. SPINNING MACHINE FOR USE WITH REMOVABLE MOULDS. HEAVY TYPE.

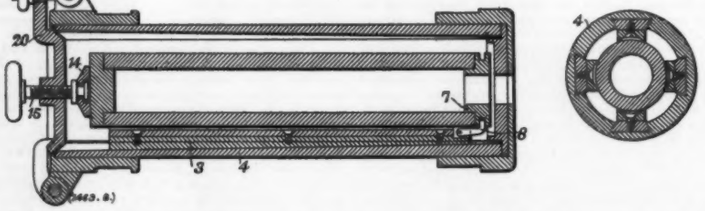
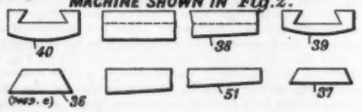


Fig.3. GIBS AND BEDS OF THE SPINNING MACHINE SHOWN IN *Fig.2*.



Mechanics of Centrifugal Casting.

10. In the first place, a clear distinction should be made between casting about the horizontal and about the vertical axis, and also the intermediate case of an inclined axis. In casting about a horizontal axis the metal is distributed symmetrically about the axis of rotation, and if the axis of rotation coincides with the axis of the spinning unit, a tube of uniform thickness is produced for the entire length of the mould. If a vertical axis is used it is obvious that the external wall of the casting follows the shape of the mould while the interior of the casting forms a paraboloid of revolution, the elements of which depend on factors given in a third appendix. In casting with the inclined axis the same general principles apply, with the further complication that the elements of the inside paraboloid of revolution are also affected by the angle of inclination of the axis to the true horizontal.

11. The usual way of casting is by introducing molten metal into the spinning mould. Where the chilling of the metal is extremely rapid, as, for example, in casting cast-iron pipe against a water-cooled chilled mould, it is imperative to use a movable spout, the latter sliding at a certain predetermined rate so that by the time the nozzle discharging the metal comes out of the mould the entire pipe is completed. This is the process employed by De Lavaud. Other manufacturers working with the cold mould have attempted to secure the same results by what is known as a trough spout, which is really a trough into which the entire metal of the casting is poured at a rapid rate. The trough is then tipped and discharges the metal suddenly, the metal falling on to the walls of the mould at such a rapid rate that a pipe forms before the metal has had time to chill. Hitherto this process has met with only indifferent success.

12. A better result has been achieved on comparatively short castings, however, by the use of a ledge spout, the spout ending in a flat ledge along which the metal can flow the entire length of the casting. Finally, where a hot mould is used an ordinary short spout is employed, the metal distributing itself throughout the mould longitudinally under one of the components of centrifugal pressure or pressure produced by centrifugal action. This arrangement cannot be used with the cold mould.

13. In centrifugal casting the distinction should be clearly made between jobbing work and mass production. For the former, clay moulds in iron cases have been used practically exclusively, as it would not pay to make a permanent mould for only a few castings. When it comes, however, to production on a tonnage basis, such as tubing or pipe, a permanent mould is practically the only feasible way of doing it. Crucible graphite or zirconium tubes have been successfully used for castings not in excess of 3 ft. in lengths, but when it comes to longer ones, metal moulds are to be preferred. Fairly successful results have been obtained with chrome-nickel alloys, though it is not expected that this will be the material finally adopted, as enough work has been done already on the production of cast tungsten to make it certain that a mould of this still rather mysterious material will be available within a comparatively short time.

14. There are several ways of supporting the mould in the spinning bench, depending on whether the mould is a permanent fixture or removable and also depending on the size of the mould. Where the mould is a permanent fixture as it is to-day wherever a cold mould is used, any kind of bearings, providing they are substantial enough, may be used. With removable moulds the conditions are somewhat different, especially where the mould is heated to a high temperature. (It will be shown later that the temperature of the mould at the time of pouring the metal may be as high as 2,000 deg. F. Where extremely hot moulds have to be used, the arrangement must be such that the stresses on the mould can be reduced to a minimum, and that the mould can be rapidly and easily inserted into the machine and extracted therefrom. The matter of stresses is of very great importance in view of the fact that, especially in large machines, the bursting stresses due to the action of centrifugal force are of such magnitude as to require the most serious consideration.

15. The spinning bench for such removable moulds as shown in Fig. 1 works on a comparatively simple principle, the mould being held in a barrel rotating on rollers, on which the pressure is adjusted by the wheel and screw shown at the top of the A frame. This figure does not show the method of supporting the mould, and moreover, except for the very small sizes, three rollers are not sufficient. The barrel construction shown in Fig. 2 is far more suitable for use with hot moulds. Here the barrel consists of a steel shell, 4, which may be an extra heavy steel pipe, but in sizes above 12 in. has to be made as a special casting. At four to six places symmetrically spaced round the inner circumference of the shell, tapered fits, 39 and 40, Fig. 3, accommodate strips with faces machined to the radius of the internal shell, screwed on or riveted on. The fits are arranged with truncated slots as shown in the figure, and in these slots move the keys or gibs 51, the cross-section, of which is shown by 37 and 36, which indicate that the face 36–37 is of the same width from one end of the gib to the other, but the height of the trunk varies.

16. It is obvious that as long as the four gibs move through the same distance longitudinally in their tapered beds, the faces of the gibs will remain parallel to each

* Abstract of a Paper read before the American Society of Mechanical Engineers, May, 1922.

† Journal 1882, page 522.

* Proceedings, 1867, pages 149 and 150.

other, but the enclosed cylinder tangent to those faces will vary in diameter with the position of the gibs.

17. The operation of the machine is, therefore, as follows: The head, 20, is opened and the gibs pulled out a little way until the tangent cylinder is, say, a quarter of an inch larger than the external size of the mould. The mould is then inserted, preferable without touching the gibs, until it comes to bear against the abutment ring, 7, to which all the gibs are attached (for example, by hooks 8.) As the mould presses against the abutment the latter recedes and carries with it the gibs, which by moving in their tapered beds gradually contract until they come to grip the mould, and they may be made to grip it as hard as desired simply by exerting sufficient pressure on the abutment, 7, which may be done through the block, 14, by the screw, 15.

18. The important advantage of this construction lies in the fact that, first, the mould automatically finds its own centre, and, second, that it is supported all along its length, a matter of great importance when we come to deal with the bursting stresses in the mould. Whether a solid or a split mould should be used is a matter determined primarily by the shrinkage condition of the metal of the castings and the metal of the moulds. Where the shrinkage conditions are such that the casting comes out of the mould easily, that is, where it contracts quicker than the mould, a solid mould may be used, but where the shrinkage conditions do not guarantee easy extraction of the casting, or where the shrinkage conditions are non-uniform, the use of a split mould has been found advisable. Such moulds are usually split longitudinally, and the question of the best method for holding the two parts together is far less simple that it appears at first sight. There are numerous patents showing the two split parts of the mould held together by bolts. In actual construction, however, the use of bolts for this purpose is entirely unsuitable, as may be shown by the following simple calculation.

19. Assume that a standard 6-in. pipe, weighing 20 lb. per foot is being cast in a mould 6 in. inside and 8·8 in. outside diameter, weighing 100 lb. per foot, and that the spinning speed is such that each pound of metal exerts a centrifugal stress of an average of 100 lb. The total stress per foot of length of mould is, therefore, 120 × 100, or 12,000 lb., and this stress has to be borne at the bolts. If there are two bolts per running foot of mould, each bolt has to carry 6,000 lb. According to *Machinery's Handbook* (edition of 1917, page 766, line 13 of table), to carry such a stress the bolt, *cold*, would have to be 1¾ in. in diameter. Such a bolt it would be impossible to put into a wall 1·4 in. thick, which has been assumed above, but at 2,000 deg. F., which is the temperature at which the mould may have to work in the hot-mould process of centrifugal casting, the metal of the bolt has not more than 20 per cent. of the strength that it had when cold, which means that either bolts of prohibitive size would have to be used or the operation of a split mould held together by bolts would be extremely dangerous.

20. To meet this condition the mould shown in Fig. 4 has been developed. This mould has side lugs machined in such a manner that when the two parts are put together a tapered clip, such as 6, can be used, and dovetail lugs, 5, are provided to engage with the taper 6. It is obvious that when the taper piece, 6, is driven hard over the dovetail lugs, 5, it will hold it tight. Furthermore, both the tapers and the dovetails can be made within reason practically as heavy as desired, so that a good factor of safety can be provided to take care of bursting stresses in the mould. To close or open the mould, it is only necessary to apply pressure to the taper piece or give a light blow, and by means of a simple jig the blow or pressure can be applied to all the taper pieces on the mould at once.

21. Such a construction diagrammatically is shown in Fig. 4. It is obvious, however, that the presence of the lugs makes the machining of the mould to a true cylinder expensive, if not impossible. Because of this, instead of machining the mould to a cylinder, a number, such as four, of flat faces are planed on the mould, the location of the faces being such that they will be distributed symmetrically around the longitudinal axis of the mould and that they will be tangent to a circle described with the point on the axis of the mould as a centre. Such an arrangement is comparatively easy to carry out and it gives an excellent support for the mould, besides providing a structure of good dynamic-balance properties.

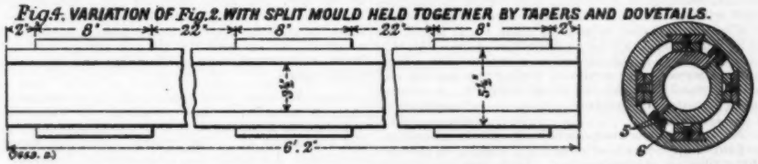
22. As regards the foundations and bearings for centrifugal-casting machines no special design need be described here, but it should be most clearly and strongly emphasised that both the bearings and the foundations should be of very generous proportions and most substantial design. The machine in centrifugal casting is subject to quite violent strains, and unless it is properly built it is apt to get into vibrations which sooner or later may have a dangerous effect. The writer knows of a case in an American plant where a centrifugal-casting machine located in a ditch and built with insufficient ruggedness actually jumped out of the ditch during operation, endangering the lives of those around it. With steel and concrete amply available there is no excuse for such practice.

23. Up to about two years ago very little work, as far as the writer knows, had been done successfully on the problem of casting centrifugally comparatively thin sections, say, under ½ in., in such metals as steels or monel and in lengths beyond 3 ft. On the other hand, large castings in brass, bronze, cast-iron and even steel have been made with considerable success. The reason for this lies in the failure to understand the thermal conditions in the mould and the process underlying the freezing of the metal.

24. There is a basic difference between casting in a stationary mould and in a spinning mould. In making castings in the former, whether it be a simple ingot or a complicated casting from a pattern, the foundryman has means to provide for the escape of gas from the metal and for taking care of the cavities produced by contraction in cooling. In a casting from a pattern, sink heads are provided, while in an ingot casting the top of the ingot acts as a sink head, in addition to which special methods such as "dozzling" may be used to keep the top of the ingot hot as long as possible, and increase the efficiency of the ingot top in performing the functions of the sink head in moulds. In both cases the foundryman is prepared to discard as defective a certain part of the casting (the ingot head, risers, sink heads) and his skill lies partly in reducing the quantity of discard as far as possible and especially in directing the process so as to restrict the presence of defective metal to the parts which he is prepared to discard.

25. In centrifugal casting, however, there is no riser or anything corresponding to the ingot top, and the cooling proceeds essentially at a uniform rate all along the length of tubular shape. It is obvious, especially in tubes of small diameter and considerable length, such as 6 in. outside diameter and 16 ft. long, that the loss of heat inward must be extremely small, because the entire inner air cylinder is surrounded by metal at approximately the same temperature. Heat is therefore, lost mainly outward to the mould and through it to the air. As a result of this, the part of the casting in immediate contact with the mould chills first. The problems with which the "centrifugal" foundryman has to deal are essentially the same as those which confront the man pouring into stationary moulds, and these are, first, to get rid of the occluded gases, and, second, to take care of contraction cavities. As regards occluded gases and slags, it would appear at first sight, especially to those familiar with such centrifugal processes as

Fig. 4. VARIATION OF *Fig. 2* WITH SPLIT MOULD HELD TOGETHER BY TAPERS AND DOVETAILS.



cream separation, that they would be eliminated automatically; pure metal, being heavier than either slag or metal containing gases, should be thrown to the outside, against the wall of the mould, while all impurities should go to the inner wall. This does actually happen, provided one condition is satisfied, and that is that sufficient time is available; and it should be remembered in this connection that this separation takes place at a fairly slow rate because of the great viscosity of molten steel.

26. The second problem is that of cavities formed in the casting as a result of contraction in cooling. As stated above, the part of the casting in immediate contact with the mould chills first. In doing so, it contracts, and if left to itself, might easily form contraction cavities and thin spots. If, however, the rest of the metal is still in a liquid state, it is projected, with a pressure at the rate of, say, 100 lb. per pound of metal, against the chilled layer, and fills all possible cavities with an efficiency many times greater than can be obtained with sink heads in stationary casting. (To obtain the same results in a stationary mould, it would have been necessary to put into the sink head 99 lb. of metal for every pound of metal in the actual casting, a proposition that is not likely to appeal to a sane foundryman.) This again presupposes, however, that the cooling proceeds at a fairly slow rate, and enough time is available for each succeeding layer to take care of chill conditions in the preceding layer. In cold-mould centrifugal casting, which means with a mould warmed only enough to take off the chill, say, 300 deg. F. to 400 deg. F., temperature conditions do not favour slow cooling, which is one of the reasons of the many past failures to produce thin-walled steel tubing by centrifugal casting. On the other hand, very excellent steel tubes (both plain carbon and nickel alloy) have been produced with diameters ranging from 10 in. up, and wall thicknesses up to 3½ in. In the latter case there is so much metal in comparison with the area in contact with the mould that enough time is available to produce a good segregation of impurities inward before the inner wall freezes.

27. It would appear, therefore, that the secret of producing centrifugally thin metal castings (under ¼ in.) lies in establishing conditions under which the cooling of the molten metal will proceed at a fairly slow rate. This applies, of course, only to such metals as steels and monel, but not to bronze, which is governed by different conditions. In the Cammen process this has been accomplished by preheating the mould to a temperature close to the melting point of the metal itself, which may vary from, say, 1,600 deg. F. to 2,000 deg. F. for steel and monel-metal castings. Under these conditions, a $\frac{1}{16}$-in. wall takes about 45 sec. to 60 sec. to harden entirely, which is sufficient to produce clean metal. Casting in such extremely hot moulds is a rather novel procedure, and at first one might anticipate trouble due to oxidation and warping of the moulds and the difficulty of handling big moulds conveniently. As a matter of fact, however, with proper equipment it offers comparatively few difficulties. The question of oxidation of moulds is taken care of by using proper alloys, such as alloys of a nickel-chrome base or cast tungsten (the latter is not yet being done on a commercial scale). The question of warping is partly taken care of by the same use of proper alloys, but mainly by the use of extremely substantial moulds and proper facilities for handling them between the casting machine, the transfer table and the furnace. In all this handling, the moulds have to be properly supported throughout the entire length, either by carrying them on a very heavy "horn" extending from one end of the mould to the other, or in a cradle supporting the mould throughout its length.

28. The method of operation is as follows: The mould with its casting inside, both at a temperature well above white heat, are rapidly pulled out from the casting machine and carried over to what is known as a transfer table, where the casting is pushed out of the mould by a hydraulic plunger. While the casting is going to the proper rolls or benches, the mould itself is coated inside by a protective layer and carried over to a reheating furnace. The furnaces used in this connection do not differ essentially from the billet-heating furnaces in tube mills. The mould coating is intended to protect the metal of the mould from coming into direct contact with the molten metal of the casting and need not be more than, say, $\frac{1}{32}$ in. to $\frac{1}{16}$ in. thick. It consists of some refractory material like alumina, zirconia, kaolin, electrically-calcined magnesia, or the like. Either pitch with some addition of solvent naphtha or clay may be used as a binder, the former being preferable as it contains no water. The coating may be applied either by a swab or through a compressed-air gun.

29. The transfer table referred to above cannot be described here owing to lack of space. It is a somewhat cumbersome piece of apparatus which may weigh from 2 tons to 10 tons, depending on the sizes of the castings handled, and is a practically self-contained unit operated from a cab by pulling a series of levers one after another.

FIELD OF APPLICATION OF HOT-MOULD CENTRIFUGAL CASTING.

30. The particular feature that determines the field of application of hot mould centrifugal casting is the ability to produce cast shapes of comparatively thin metal (down to ¼ in.) in great length, with our present knowledge of the art up to 20 ft. One of the first applications that comes to mind is in the production of seamless tubing.

31. Hitherto the principal tonnage of seamless tubing has been made by the Mannesmann piercing process and its variations. Essentially this process consists in imparting such a twisting motion to a steel billet as to break down its central fibres. This motion is set up by means of obliquely placed rolls or discs. There are several objections to this process. In the first place, while it does pierce high-grade mild steel or Muntz-metal billets, it stresses the central part of the billet far beyond its elastic limit. While apparently this does not affect very seriously the tensile strength of the finished product, after it has been cold-drawn or hot-rolled, there is good reason to believe that it impairs the resistance of the metal to corrosion, the latter, as we know now, being particularly active in the case of metals stressed up to or beyond the elastic limit. Furthermore, the Mannesmann process is not at all applicable to metals which are either extremely tough or very brittle. Thus, all attempts to produce commercially by the Mannesmann process, hollow billets of either monel metal or Admiralty brass have so far failed. Not only that, but the Mannesmann process, by its very character, is limited to the production of comparatively small sizes, not in excess of 6 in. in diameter; while experimentally larger sizes have been made, the 6-in. limit has been pretty well established for standard commercial grades. It is obvious that as we go up in sizes, the piercing mills used in this process increase in cost with great rapidity, and as the cost of even a small Mannesmann mill easily runs into six figures, the cost of the big ones becomes prohibitive after passing a certain limit, which is round 6 in.

32. At the same time there is a demand for larger sizes of tubing of greater strength than a single-welded joint can give and this is where the most obvious field of hot-mould centrifugal casting appears. With this process, tubing in extra heavy and double extra heavy thicknesses can be easily produced in sizes up to 24 in. in diameter at a cost per ton that can compete with plain welded tubing and it is considerably lower than that of double-welded tubing such as is used for hydro-electric installations.

33. The next field of application in connection with steel tubing is in standard sizes from 6 in. to 14 in. up, where welded tubing is now used exclusively. Such pipe can be produced in two ways: First, by casting a hollow billet of wall thickness two to three times that of the finished pipe, and either cold-drawing or hot-rolling it to size. In such a case the billets cast would be roughly 8 ft. to 10 ft. long so as to have, say, 22 ft. in the finished pipe, barring cropped ends. The other method is to cast the pipe direct with only a slight excess of wall thickness and then to give it one pass between straightening rolls over a ball, so as to reduce the diameter and wall thickness to exact size with standard tolerances, and give the exterior and interior walls a finished appearance. From data now available it would appear that the final cost of both kinds is approximately the same, and is well within the range at which centrifugally cast-steel pipe can compete in price with welded pipe.

34. It is only natural that this should be so. In pipe, manufactured by the standard processes, steel is cast in ingots, which, after cropping and several thermal and

mechanical operations, are rolled into skelp. The skelp goes to a pipe mill, is heated to a red heat and rolled to bevel edges, after which it is sent through the bending rolls. It is next reheated to welding heats and in succession passed through welding rolls, sizing rolls and finally straightening rolls. Each of these operations is done, of course, by appropriate machinery developed to a remarkably high state of perfection, but nevertheless each operation adds its mite to the final cost of the article, and this mite is not inconsiderable in view of the immense tonnage produced. In centrifugal casting the metal is poured into the mould which corresponds to casting the ingot, and the casting is then ready to go to the final rolls, which can be done without reheating. There is at least 50 per cent. less handling of material in centrifugal casting than there is in making pipe by welding, and such a difference cannot help being reflected in costs.

35. In this connection it might be well to mention one of the psychological factors with which centrifugal casting is concerned, and that is, the not unfounded distrust of users of metal products toward castings, especially those in thin sections. Such castings cannot be produced commercially in a stationary mould, and steel castings in a stationary mould as made to-day generally are of such physical properties as to be usable only where they are not subject to complicated stresses and where an extremely high factor of safety can be provided. Wherever the stresses are high and especially uncertain and the factor of safety is not more than ample, no engineer to-day will use a casting, but will insist on either a forging or a piece machined or hot-rolled.

36. This not unfounded distrust of castings is due to the fact that in either the sand casting or chill casting the temperature conditions in the metal are uncontrollable, with the result that one part of the metal may be entirely different in its physical properties, such as hardness and crystalline structure, from the other, and there is no guarantee that two castings made under apparently the same conditions will be entirely alike. There is too much individuality in products cast in stationary moulds to make them suitable for engineering requirements where a failure would be disastrous, and where only moderate factors of safety may be employed. The situation is, however, entirely, different with centrifugal castings, because there ample facilities are available, especially in hot-mould casting, to control the rate of cooling of the metal, and the nature of the process is such as to tend to give a uniform product, provided, of course, the process is carried out properly. From this point of view, one cannot help agreeing with an editorial in the *Iron Age* (February 9, 1922), which states that "the successful operation of centrifugal casting processes insures a product, no matter of what composition, which is of a high grade. It is a realisation of quality production in quantity, for rapid output is a marked characteristic. There is also the advantage of the elimination of sand and dirt. The condition of casting and cooling tends to produce a dense casting and one whose microstructure is different from the sand-cast products. Centrifugal force is substituted for sink heads as an insurance against unsoundness." This brief analysis in the *Iron Age* states strikingly the difference between sand castings and centrifugal castings, and explains the reason why centrifugal castings may be used on a par with forged or hot- and cold-worked metal where sand castings would be too hazardous.

37. But the field of application of centrifugal casting, especially of the hot-mould type, does not stop with plain carbon steels. There are a number of alloy steel which it would be very desirable to have in tube form, such as stainless steel, high-speed tool steel, chrome-nickle-vanadium steel and the various "near-steels" which are iron alloys with a predominance of materials other than iron, such as heat-resisting alloys. Practically none of these materials will stand for piercing by the Mannesmann process, but cast with great ease into tubular shapes. In fact, even Hadfield manganese steel has been found to make, by centrifugal casting, excellent tubing, although it is very doubtful if it has any commercial application outside of some very limited specialties.

Plate Manufacture.

38. Centrifugal casting is peculiarly applicable to the manufacture of plates. Andrew Shanks, the British inventor of the middle of the 19th century, to whose pioneering work in the manufacture of cast-iron pipe reference has been made above, was also the earliest manufacturer of plate. His process was to cast a thin-walled pipe, cut it, and then by careful annealing and hammering, flatten it out. The process was kept secret and was successful commercially until rolled steel sheet was put on the market.

39. The use of a hot mould makes it possible, however, to secure comparatively thin-walled castings in large sizes. A process has been worked out, though not yet applied on a commercial scale, in which a cylindrical casting is made in such a manner that a longitudinal split of about half an inch wide is produced. The split cylinder as it comes from the mould is sent first through a flattening jig where it is flattened out on its own heat, and then to rolls, of which there are at least two, one for sizing and the other for finishing. Under certain conditions more than one sizing roll may be required. The casting has to be cast oversize, the wall thickness being from 10 per cent. to 15 per cent. greater than that of the finished plate. Thus, for example, ½-in. plate would be cast in sizes 240 in. long, 20 in. in diameter and 0·265 wall thickness. It is expected that it can be brought down to a ¼ in. in one pass in the sizing rolls and that no reheating would be necessary.

40. This process is to-day only in its initial stages of development. It is attractive, however, as it does away with the ingot-casting work, soaking pits, blooming mill and a great share of the rolling equipment, permitting a conversion from molten metal to finished plate estimated at about 4.00 dols. per ton.

41. Not only that, but it also makes quite attractive the manufacture of alloy-steel plates, in particular, of such material as acid-resisting steels for use in chemical tanks and the like. These steels are very difficult to roll. The final product could stand the cost of the two or three passes necessary in centrifugal casting of plates, but not the many operations of the conventional methods of plate manufacture, the main item of expense being not the actual rolling but the complicated heat treatment absolutely imperative between the rolling operations. In fact, it would not be surprising if with prices of alloy-steel plates brought within reason, they would be used far more extensively than one would expect to find from present indications.

42. The casting of gears by centrifugal methods, in particular worm and herringbone gears, has been achieved with great success both in England and in America, especially in this country. As far as the writer is aware, however, all such gears have been cast in non-ferrous metals and not in steel.

43. There is one more field of application of centrifugal casting, especially the hot-mould type, comparatively small to-day, but which may become of material interest shortly, and that is the production of cylinders requiring extremely high strength. When the oxygen industry first called for cylinders that would safely withstand 2,000-lb. pressure to the square inch, it looked like a big problem, but it was solved by the progress in the cupping process. When, however, the Haber synthetic ammonia process demanded great pressures combined with considerable temperatures, special expensive tools had at first to be provided for machining the cylinders required from solid stock. The Claude ammonia process goes to temperatures and pressures far exceeding those of Haber, and the experiments of Professor Bridgman of Harvard University and others point to the likelihood that before many years are past pressures of the range of 100,000, 200,000 and possibly even more pounds to the square inch will be used commercially. At pressures between those used by Haber and Claude and those used by Professor Bridgman for containers of commercial size, carbon steels are but little suitable and the vessels required will have to be made from alloy steels.

44. This may be done in two ways, either directly by centrifugal casting on a vertical axis which would give a vessel with closed bottom, or by the cupping process from alloy-steel plates, which, in their turn, would be made by centrifugal casting as described above. In this connection it may be of interest to mention that a high measure of success was achieved during the war by the Bethlehem Steel Company, at Bethlehem, Pa., in casting air flasks for torpedoes centrifugally in a machine running on a vertical axis.

45. No attempt has been made in the above discussion of the field of application of centrifugal casting to present anything like an exhaustive list. Instances have been merely cited to show the enormous field in which this process is or may be employed.

46. The same applies largely to the description of the mechanics of the process, where likewise no attempt has been made to show the historical development of machinery for centrifugal casting or to give details of the actual apparatus. The apparatus has been shown mainly in order to give an idea of the kind of machinery that has to be used.

47. In connection with the mechanics of centrifugal processes it seems appropriate to remark at the close of the paper so as to give it the greatest emphasis possible, that the machinery itself is, and should be, comparatively simple, for the process when properly worked out is the acme of simplicity. It should be, however, clearly understood that in centrifugal casting we are dealing with large rotating masses and with metal subjected in its molten state to the effect of great force.

48. Furthermore, the distribution of the metal in the mould is effected primarily not by rigid material visibly distributed as in stationary casting, but by the action of invisible forces which do not come into operation until the moment when the metal is delivered to the mould.

49. Because of all this, and notwithstanding the great simplicity of the machinery and methods of centrifugal casting, it should be clearly remembered that even the slightest imperfection in the design or operation will immediately show up in the casting.

50. Centrifugal casting is a process which it is peculiarly impossible to work either by slipshod methods or on a shoestring, i.e., skimping on the quality of materials and on factors of safety in the design of machinery.

51. There is an old saying current among moulders to the effect that a lie in sand will be shown up in the metal. The same applies with still greater force to centrifugal casting. The slightest mistake in the layout of the machinery or use of poor materials in the machine, its bearings and foundations, will produce an uneven casting, result in excessively rapid wear of the moulds, and at times may even cause disastrous accidents with danger to life. At the same time, with good engineering and the use of first-class materials, centrifugal casting may be carried on entirely by semi-skilled labour and still give products of unsurpassed excellence.

United States Output of Iron and Steel.—The output of pig-iron in the United States during June totalled 2,361,000 tons, the highest figure in any month since January, 1921. The steel ingot production is 2,634,000 tons. General production in the steel industry is estimated at about 75 per cent. of capacity. The United States Steel Corporation's unfilled orders at the end of June amounted to 5,636,000 tons.

CATALOGUES.

Manganese Steel.—A booklet issued by Messrs. Samuel Osborne and Co., Limited, Sheffield, contains a number of illustrations of tramway and railway point work and crusher jaws of manganese steel.

Oil Well Plant.—A book of 50 pages received from the Oilwell Supply Company, U.S.A. (Dashwood House, London, E.C. 2), contains many striking views of the machinery for working oil wells taken of actual installations.

Reinforced Concrete Roads.—A substantial volume containing over 150 pages of illustrations of reinforced concrete roads finished or in process of construction is to hand from the British Reinforced Concrete Engineering Company, Limited, Trafford Park, Manchester.

Electrical Machines.—A further list of motors and dynamos in stock is to hand from the A.C.E. of Charleroi, whose London address is 56, Victoria-street, S.W. 1. The firm have also sent a 12-page catalogue describing their motor converters with automatic self-synchronising device.

Motor Cars.—The Ford Motor Company, Limited, Trafford Park, Manchester, have sent us a catalogue describing the Ford-Lincoln car, made at the firm's Detroit works. The engine has eight cylinders of 3⅛-in. bore and 5-in. stroke, and there are 10 standard bodies to select from.

Power House Equipment.—A booklet containing an illustrated description of the boiler, turbine, generator switchboard and coal and ash plant of the Blackburn East Power Station has been received from the English Electric Company, Limited, Queen's House, Kingsway, London, W. C. 2, which, with its associated firms, carried out the whole of the work.

Driving Belt.—A driving belt of V cross-section, in which the links are made up of layers of leather and of hard non-stretching fibre, is described in some leaflet catalogues received from the Automotive Products Company, Limited, 3, Berners-street, London, W. 1. It is suitable for driving fans and dynamos on motor cars and for other light drives.

Steam Engines.—A clear explanatory catalogue of small stationary steam engines of from 3 h.p. to 30 h.p. or 40 h.p. has been received from Messrs. Marshall, Sons and Co., Limited, Gainsborough. The tables included give the effective horse-powers at steam pressure of 60 lb., 80 lb. and 100 lb. per square inch, both the most economical working loads and the maximum loads being stated.

Blast Recorder for Cupolas.—It is, of course, advantageous to record the quantities of coke and iron supplied to a cupola, and it is also desirable to measure the volume of air. The Crosby Valve and Engineering Company, Limited, 41, Foley-street, London, W. 1, have therefore made a blast-recorder for this purpose, and a catalogue relating to the instrument recently received from the firm contains some useful general notes on cupola practice.

Flexible Piping.—A flexible pipe joint made by Messrs. W. H. Dorman and Co., Limited, Stafford, is described in a special catalogue which has reached us from that firm. It is of the ball and socket type, and is made to interchangeable standards in sizes from ¼ in. to 12 in. internal diameter. It is made with screw or flange connections, in various metals, and is suitable for water, steam, petrol, oil or any ordinary liquid, as well as for conveying ashes, small coal, &c. Full particulars, with prices, are given in the catalogue.

Planing Machines.—High-speed planing machines in a range of nine sizes, from 4 ft. to 12 ft. in length, and capable of taking work from 24 in. to 60 in. square, are shown in a special catalogue received from the Butler Machine Tool Company, Limited, Halifax. The belt-driven machines have a return speed 2½ times the cutting speed, and the makers state that a much higher ratio of return speed involves disadvantages which more than counterbalance the saving of time. Electric drives by belt or by direct reversing motor can be fitted if desired.

Tool Steels.—A number of intermediate steels (between high-speed and ordinary carbon steels) are described with regard to their qualities, special uses and heat treatment in a catalogue from Messrs. Edgar Allen and Co., Limited, Sheffield. For particular purposes, or under certain conditions for which carbon steel would be almost or entirely unsuitable, the intermediate steels are as efficient as the high-speed steels, and are more economical. The tools include nearly all the usual turning, screwing, reaming, drilling and other forms, the selection of the steel employed depending on the working conditions. Other steels specially useful for making setts, hot dies, and dies for producing screw threads by the rolling process are also described.

The Schoop Metal-Spraying Process.—Recommending his metal-spraying process especially to shipbuilders, for providing chains, cranes, ship's bottoms, propellers, &c., with protective coatings of zinc or copper, M. U. Schoop mentions in *Schiffbau*, of June 21, that the French Navy successfully kept two large zinc-sprayed riveted sheets of iron, 12 mm. thick, in sea water for five months, and that the Swiss Railway Department has put up thousands of skeleton towers sprayed with zinc, also with good results. Eighteen cast-iron lined wells in Zurich, incrusted with bronze or copper, are now, after 10 years' service, reported still to be in perfect condition. Aluminium spraying is also recommended for castings, valves, condensers, &c., made of steels, copper, and bronze, and for parts which will have to withstand high temperatures.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

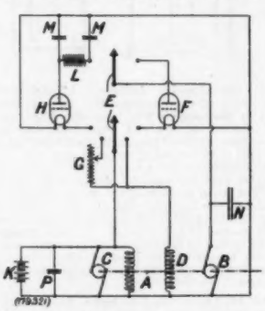
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

176,220. F. Young, Rochester. Adapters. (2 *Figs.*) January 28, 1921.—This invention relates to adapters for use in connection with electric lighting and other circuits. According to the invention, an adapter for use in connection with electric lighting and other circuits comprises a body 1 of insulating material having holes 5, 7 for the passage of the electric cable through it, the holes being closed at one of their ends by metal plates 10 which constitute contacts to the underside of which

the electric conductors 6 are secured and are held in position by screws 9. Preferably two holes 5, 7 are provided, one for each conductor, which holes enter a common central longitudinal hole through which both conductors pass from the adapter. Preferably also the metal plates 10 constituting contacts are sunk into the face of the end of the adapter and the electric conductors are clamped between the plates and washers 11. (*Sealed.*)

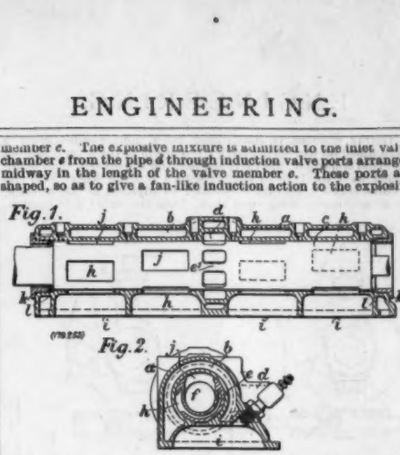
179,321. P. P. Eckersley, Witham, J. M. Furnival, South Hampstead, London, H. R. C. Van de Velde, Hurlingham, London, and J. Stewart, Junior, Newton Stewart, Scotland. Valve Amplifiers. (1 *Fig.*) February 5, 1921.—In wireless signalling as now practised thermionic devices are frequently employed for the purpose of amplifying the electric currents. According to this invention, the high tension current both for transmission and for reception purposes is supplied by the same rotary machine. On a shaft A are mounted a high-tension rotor B and a low-tension rotor C which supplies current to the field winding D of the rotor B. This current is controlled by a switch E, which, on being thrown to the right, allows the field to be fully excited and therefore the full voltage of B to be applied to the transmitting valve F and also allows current from C to be applied to the filament of that valve. When, however, the switch



is thrown to the left, the transmitting valve is cut out, resistance G is inserted in series with winding D so that the rotor B only gives the voltage required for reception and current from rotor B is supplied to the anode circuit of the receiving valve H, and current from rotor C to the filament of that valve. K is an accumulator which is floated across the rotor C, which is thereby silenced, while the rotor B is silent during reception because its field is so weakly energised that no sparking at the commutator takes place. In order to get absolute silence a choke L and condensers M, M are arranged in the positive high-tension feed to the receiver. Furthermore there is a main so-called smoothing condenser N across the rotor B. Lastly a small condenser P is placed across the rotor C. It will be seen that the resistance G controls the value of the voltage given by the rotor B, and hence the sensitivity of the receiver. (*Accepted May* 17, 1922.)

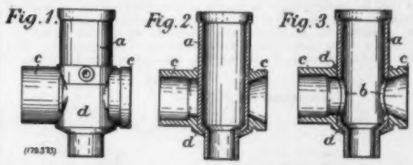
GAS ENGINES, PRODUCERS, HOLDERS, &c.

179,283. F. Shirley, London, and J. W. George, London. Internal-Combustion Engines. (4 *Figs.*) January 27, 1921.—This invention relates to valves for internal-combustion engines of the type in which a rotating cylindrical valve member is arranged above the working cylinders and contains a rotating cylindrical inlet valve chamber and a centrally-arranged tubular exhaust valve chamber, the rotating cylindrical inlet valve chamber being continually charged with explosive mixture. The casing *a* of the valve contains a rotating cylindrical valve member *c* and is also suitably water jacketed at *b*. The valve member *c* contains a rotating cylindrical inlet valve chamber *e* and a central tubular exhaust valve chamber *f* communicating with an exhaust pipe. The inlet valve chamber *e* communicates with ports in the cylinders *i* through ports *h* in the valve member *c*, and the exhaust valve chamber *f* communicates with the ports in the working cylinders *i* through ports *j* in the valve member *c*. The explosive mixture is admitted to the inlet valve chamber *e* from the pipe *d* through induction valve ports arranged midway in the length of the valve member *c*. These ports are shaped, so as to give a fan-like induction action to the explosive



mixture. The rotating member *c* is operated from a working part of the engine, and is preferably held from longitudinal movement by screwed caps *k* and washers *l* which allow for easy access to the rotating sleeve. (*Accepted May* 17, 1922.)

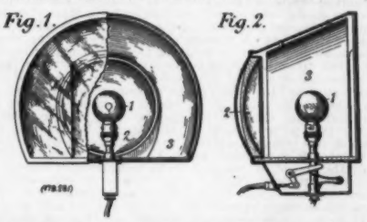
179,373. Brown and Barlow, Limited, Witton, Birmingham, and C. Brown, Birchfield, Birmingham. Carburettor Bodies. (3 *Figs.*) March 10, 1921.—This invention comprises certain improvements in carburettor bodies. According to the present invention, the carburettor body is manufactured from a length of tube, to which latter an inlet and/or outlet is applied by casting, preferably die-casting. The body of the carburettor comprises a tube *a* which may be enlarged at its upper extremity and reduced at its lower extremity by any



appropriate process. In order to provide a passage transversely to the length of this tube aligned openings *b* are provided on opposite sides thereof, and aligned bosses *c* extend radially outwardly from these openings *b*. These aligned bosses *c* are cast on to the vertical tube *a* by a process of die-casting, in which the metal applied by the die-casting process is adapted completely to encircle the vertical tube *a* forming a sleeve or collar *d*, from opposite sides of which the boss-like projections or conduit portions *c* integrally project. (*Accepted May* 17, 1922.)

MOTOR ROAD VEHICLE.

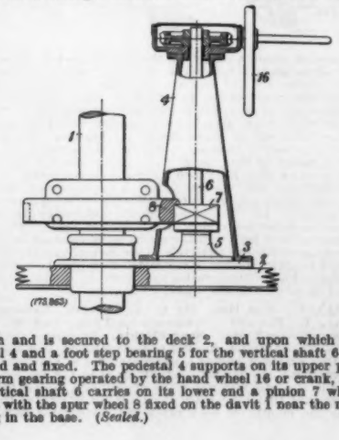
179,281. H. C. Gibson, Oldstede, near Sittingbourne. Head Lamps. (3 *Figs.*) February 1, 1921.—According to the present invention, a head lamp has a mirror 2 arranged at the back of the light source 1, and a second mirror 3 arranged over the top of the light source, with or without extensions down the sides to reflect light down on to the road. The mirror 2 is pre-



ferably a parabolic mirror of long focal length to produce a long search beam. The source of light 1 may be movable up or down in relation to the mirrors; this provides means to throw the long search beam down on to the road to prevent glare should it be found that a person is approaching. (*Sealed.*)

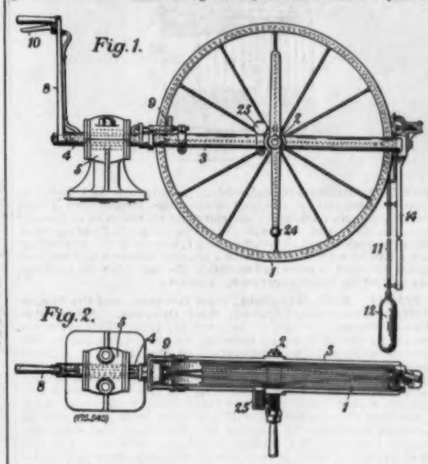
SHIPS AND NAUTICAL APPLIANCES.

173,863. G. Turnbull, Claughton. Ships' Davits Turning or Slewing Gear. (3 *Figs.*) October 8, 1920.—This invention relates more particularly to such davits as are mounted upon vertical axes and are turned and slewed by means of hand-operated worm and worm-wheel gear. According to the invention, the davit bearing is formed on a strong base plate 3 which



rests on and is secured to the deck 2, and upon which the pedestal 4 and a foot step bearing 5 for the vertical shaft 6 are mounted and fixed. The pedestal 4 supports on its upper part the worm gearing operated by the hand wheel 16 or crank, and the vertical shaft 6 carries on its lower end a pinion 7 which meshes with the spur wheel 8 fixed on the davit 1 near the neck bearing in the base. (*Sealed.*)

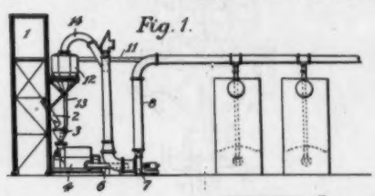
175,540. R. N. Prince, Watford. Sounding Apparatus. (3 *Figs.*) February 25, 1921.—The invention relates to sounding apparatus. A drum 1 is mounted free to revolve on a spindle 2 in a rectangular frame 3 carried on a shaft 4 supported in a bearing 5 on a platform so as to overhang the side of the vessel. The shaft 4 is provided with a handle 8, and a brake 9 holds the drum 1 stationary when the line is wound on it. The brake 9 is operated from an operating lever 10 on the handle 8. The line 11 is wound on the drum 1 and passes through eyes carried on a member 14 depending from the frame 3. The drum 1 is geared to a counter 25. In operation, the counter 25 is adjusted

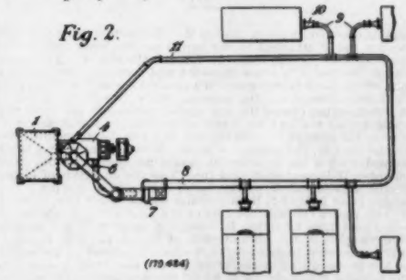


to zero when the sinker is at the surface of the water. The sinker is then wound up and the frame 3 is swung backwards and forwards, or is rotated, by means of the handle 8, until the sinker 12 has acquired sufficient velocity, when the brake 9 is released and the sinker is cast in the direction of motion of the ship. The line 11 is unwound from the drum 1 until the sinker reaches the bottom. As the ship moves forward the frame 3 is slowly rotated until the depending member 14 assumes a vertical position when the depth is read on the counter 25. The line 11 is then rewound on to the drum 1 by means of the handle 24. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

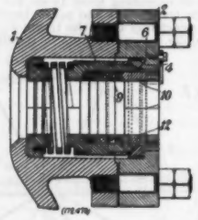
179,484. The Powdered Fuel Plant Company, Limited (*The Assignees of Société Anonyme de la Combustion Rationelle, Paris, France*). **Supplying Powdered Fuel to Furnaces.** (2 *Figs.*) May 14, 1921.—This invention is for an improved method of, and apparatus for, supplying powdered fuel to furnaces. The invention consists in extracting the powdered fuel from pulverising apparatus by an air current during the operation of the apparatus, mixing the powdered fuel and its conveying air with a further supply of air sufficient for complete combustion and supplying such final mixture under pressure through a distributing main. A container 1 for the raw fuel is provided with a discharge hopper and pipe 2 to deliver the fuel into a funnel 3 of a pulveriser 4. The dust is extracted from the pulveriser 4 by a fan and delivered through pipe 6 to the suction pipe of a main distributing fan 7. The distributing fan 7 draws in additional air to make up the whole amount required for combustion, past a flap-valve at the upper end of a vertical suction pipe, and delivers the fuel mixed



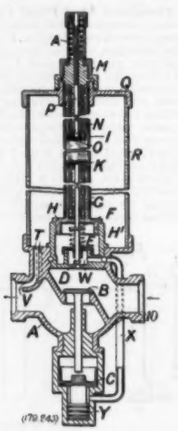


with it into a main supply trunk 8, the pressure being sufficient to ensure the proper delivery of air and fuel to all of the devices or apparatus to be supplied. The fuel-consuming devices are each supplied through branch pipes 9 connected to the respective burners 10, and the size of the trunk 8 is graduated to ensure the correct velocity and pressure being maintained in successive sections beyond each branch pipe. The trunk 8 is extended beyond the last branch pipe 9 by a return pipe 11, through which passes the air and fuel not consumed by the furnaces. This mixture is delivered first to a separator 12, and the powdered fuel collected at the bottom passes by a pipe 13 to the bottom of the funnel 3 which feeds the pulveriser; it is thereby returned to the pulveriser and withdrawn by the fan 6 and put into circulation again almost immediately, so that there is no possibility of powdered fuel accumulating in any part of the system. The air from the separator 12 is led by a pipe 14 into the vertical suction pipe for the main fan 7, so that it also is put into circulation again. (*Sealed.*)

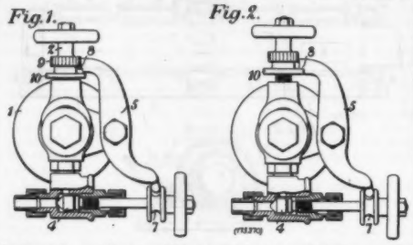
172,478. S. H. H. Barratt, Hampstead, London. Stuffing Boxes. (2 *Figs.*) October 14, 1920.—The object of the invention is to provide a stuffing-box in which soft packing only may be used, thereby eliminating scoring of the associated rod which so often occurs with metallic packings, while at the same time a lateral movement for the rod is provided, and all the advantages of metallic packings obtained. The invention consists in a stuffing-box comprising, a separate and independent packing-box 7 disposed within the stuffing-box 1 and containing soft packing 9, the tightness of which is adjustable by a movable gland 10 engaging in the packing-box 7 and operable from the open end of the stuffing-box 1, a cover 2 for the stuffing-box 1 having a fixed gland 4 with a bearing surface 6 and resilient means disposed to press and maintain the part 12 of the packing-box against the bearing surface 6. (*Sealed.*)



179,243. B. R. Wingfield, West Drayton, and the Steam Fittings Company, Limited, West Drayton. Steam Reducing Valves. (1 *Fig.*) January 24, 1921.—This invention relates to steam pressure reducing valves. According to the present invention, the temperature of the steam at reduced pressure is used to control the valve by means of a thermostat mounted on the valve body and surrounded by a housing communicating with the low-pressure side of the valve, and acting through a pilot valve. A is the valve body, B the main valve, C a piston for opening valve B controlled by a pilot valve D, normally held open by a spring E. The thermostat comprises a tube I filled with a suitable liquid and screwed to a cap H at its lower end which in turn is screwed into a sleeve portion H1 fitted into the valve body. At its upper end the tube I passes through a cap Q screwed to the housing R, and is closed by a screwed cap M. The cap M is clamped to the cap Q, and the housing R surrounding the tube I is screwed to an extension on the valve body. Inside the lower end of the tube I is fitted a member G which consists of a spirally corrugated metal tube, one end of which is secured to the cap H, the upper end of the tube being closed by a cap K carrying an operating rod F. The rod F passes through the cap H and at its lower end operates the pilot valve D, which controls a port in the chamber W, the latter being formed by a cap fitted to an extension on the valve body. Inside the upper end of the tube I is fitted a regulating member N similar to member G, having one of its ends closed by a cap O and its other end fixed in the cap M. The member N is provided with a rod P attached to the cap O on the lower end of the member, and passing freely up through the cap M. The upper end of the rod P is screw-threaded and carries a nut having a pin, which projects into a slot in a sleeve A secured to the cap M. With this arrangement the nut can turn only with the sleeve A. A strong spring presses the nut against the cap M, the other end of the spring resting upon a cap screwed to the top of sleeve A. The dotted passage T in the valve body forms the steam inlet into the housing R, the passage V being the steam outlet and being formed with a lip in order to obtain an ejector action. The chamber W is connected by a tube X to the underside of piston C, the attachment Y on the latter acting as a damper. The action is as follows: High-pressure steam enters the valve at 10 and passes through the port of the pilot valve D, the latter being kept open by spring E, filling the chamber W and passing through pipe X to the underside of piston C. The piston C is thus operated to raise valve B admitting steam to the outlet or low-pressure side of the valve whence the steam passes into the housing R and circulates round the thermostat. As soon as the thermostat reaches the temperature for which it is set, that is to say, as soon as steam of the desired pressure has been obtained on the outlet side of the valve, the thermostat member G operates and closes the pilot valve D and thus cuts off the steam supply to piston C and the valve B consequently closes. The movements of rod F may be magnified by any suitable lever arrangement as desired. (*Accepted May* 17, 1922.)

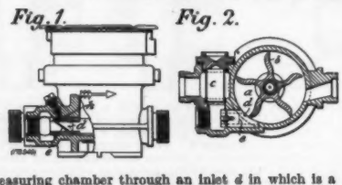


175,370. T. Taylor, Willington-Quay-on-Tyne. Oil Fuel Burners. (2 *Figs.*) November 10, 1920.—In connection with liquid fuel burners of the kind which are held in a burner holder equipped with a pinching screw serving to hold the burner joint on its seat this being part of a shut-off valve carried by the burner holder, it has been proposed to provide for the interposition between the pinching screw and the shut-off valve of an interfering element which, when the valve is opened, prevents displacement of the pinching screw, and which, when the pinching screw is operative, prevents the valve from being opened. The present invention consists in the feature that the interfering element is constituted by a double-ended lever 5 fulcrummed on the burner holder 1, one end of the lever engaging a grooved collar 7 on the valve spindle, and the opposite end being formed as a tooth 8 to engage with a toothed wheel 9 on the pinching screw 2, or with a shoulder 10 adjacent to the wheel 9, the arrangement being such that, when the valve 4 is opened, the lever 5 occupies a position in which the tooth 8 engages the toothed wheel 9, and when the valve is closed and the pinching screw 2 is moved to the inoperative position shown in Fig. 2, the lever 5 is held against movement by engagement of the tooth 8 with the shoulder 10, whereby the valve 4 is held against opening movement. (*Sealed.*)

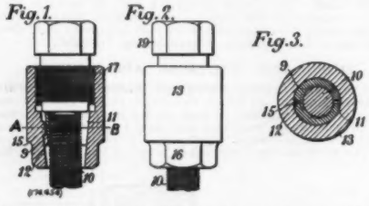


MISCELLANEOUS.

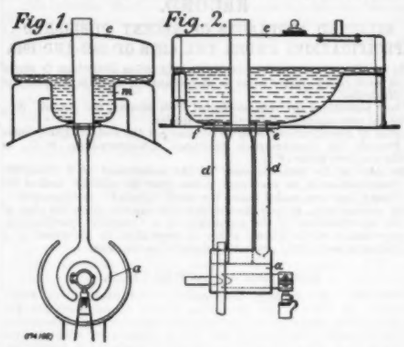
173,949. W. G. Kent, London. Liquid Meters. (5 *Figs.*) November 29, 1920.—This invention relates to liquid meters of the type in which the liquid to be measured entering a cylindrical measuring chamber impinges upon the vanes of a wheel, the consequent rotation of which actuates a counter. According to this invention, there is placed in the inlet to the measuring chamber a flap valve pivoted about a horizontal axis and means are provided for regulating the extent to which this valve can open. *a* is the measuring chamber in which is a rotor *b*. The liquid to be measured after passing through a strainer *c* enters the measuring chamber through an inlet *d* in which is a gate valve *e* pivoted on a horizontal pin. An adjustable stop *h* is provided above the gate to limit the opening thereof for the purpose of rating the meter at the full flow. When the flow is small the gate will only be opened slightly and a small jet of liquid will impinge upon the measuring rotor at a higher velocity than would happen if there were no gate and the whole area of the inlet were free to supply the required flow. In this way the jet produces an effect upon the rotor sufficiently great to ensure the meter registering. (*Sealed.*)



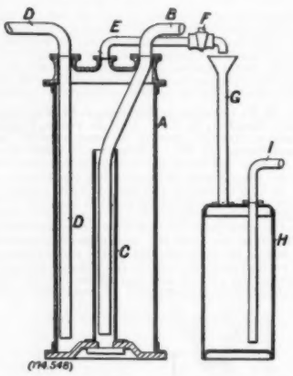
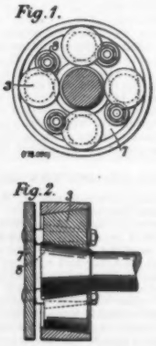
174,454. W. J. Howe, Newton Abbott. Driving or Extracting Studs. (8 *Figs.*) October 29, 1920.—This invention relates to stud drivers of the type comprising a tapered socket, a stud-gripping device located in the socket and co-acting with the taper thereof and a pressure plug screwing into the socket to cause longitudinal movement of the stud-gripping device. In the stud driver, according to the invention, the stud-gripping device comprises a split nut mounted independently of the pressure plug, and the thread of the pressure plug is of opposite hand to that of the stud. According to a modified form, the internal surface of the split nut member may be formed plain to grip the plain surface of the stud. In carrying the invention into effect according to the form shown, a split nut member 9 is provided which is internally screw-threaded to suit the thread on the stud 10 to be inserted or extracted. The outer surface of the nut member 9 is of tapered form. The nut member is split longitudinally at 11, while the outer surface diametrically opposite the split is provided with a key-way 12 for a purpose hereinafter referred to. The nut member is inserted within a socket 13, the interior surface of which for part of its length is tapered to correspond with the taper on the nut member 9. The socket is provided with a key 15 which co-operates with the key-way 12 in the nut. The screwed bore of the socket accommodates a screwed pressure plug 17, the inner end of which bears upon the nut member, while the outer end is formed as a nut for engagement by a spanner. In operation, when it is desired to insert a stud, the nut member 9 is placed in the socket so that the key 15 co-acts with the key-way 12. The pressure plug 17 is then screwed into the socket so that it just contacts with the nut; during the operation, the nut is prevented from rotating in the socket by the co-operation of the key and key-way. The device is now screwed on to the stud until it touches the pressure plug, as indicated in Fig. 1. The plug 17 is then screwed hard into the socket so as to cause longitudinal movement of the nut relatively to the socket, whereby the nut is caused to grip the stud. The latter may now be screwed into the desired object by rotating the device by means of the hexagonal surface 16 on the socket. (*Sealed.*)



174,192. The Hon. Sir C. A. Parsons, Newcastle-on-Tyne, E. Bennett, Newcastle-on-Tyne, and H. Rowe, Newcastle-on-Tyne. Searchlights. (2 *Figs.*) October 20, 1920.—The invention consists in the provision, in a searchlight or other projector having a water jacket *a* in proximity to the arc connected by pipes to a tank fitted in the projector, of a sump in the tank into which the connecting pipes are fitted and so designed that even when the projector is pointed to a high angle the mouths of both pipes will be covered with water. According to the present invention, the tank *c* is formed with a sump *m* into which the pipes *d* lead. The sump *m* is so placed and is of such shape and the openings *e* and *f* are so located that at the highest angles to which the projector is likely to be tilted the openings will always be covered with water, thus ensuring a supply of water to the jacket *a*. (*Sealed.*)



174,548. R. Philp, Woolston, Hants. Separating Oil and Grease. (3 *Figs.*) June 1, 1921.—This invention relates to an improved apparatus for recovering oil and grease from the discharge water of steamships, to prevent the pollution of harbours and docks. A cylindrical chamber A has a pipe C, which extends vertically from the bottom to within three-fourths of the height of the chamber A, and is open at the top end. Inside the pipe C is a pipe B which passes through the top cover, and extends to within a few inches of the bottom of the chamber A. An internal pipe D passes through the top cover and reaches to within a few inches of the bottom of the chamber A. At the centre of the top cover the pipe E is fitted, having a cock F attached. A cylindrical chamber H is placed adjacent to the chamber A. Secured to the top cover is a pipe G opening into the chamber top and extending to the level of the top of the chamber A. An internal pipe I passes through the top cover of the chamber H, and extends to near the chamber bottom. A cock (not shown) is fitted to the side of the chamber H. The apparatus works as follows: The discharge water from the bilge pump enters by the pipe B into the larger pipe C at its lower end. The water then flows in an upward direction and is discharged into the larger chamber A. This chamber being larger in area, the oil is allowed to rise to the surface of the water. The oil, air and a small quantity of water pass through the pipe E and cock F into the chamber H. The main portion of the water is discharged overboard by means of the internal pipe D. The oil, water and air which pass through the pipe E and cock F are discharged into the chamber H by means of the pipe G. In this chamber the oil is again allowed to rise to the surface of the water, and the water is discharged by means of the internal pipe I into the bilge. At a certain period the oil is drawn off from the chamber H by means of the cock. (*Sealed.*)



178,030. G. M. Cameron-Cowburn, Gosport. Friction Gearing. (2 *Figs.*) June 7, 1921.—In frictional epicyclic gearing, in accordance with this invention, of the kind in which conical planet wheels are mounted between internally and externally coned members, the rollers 3 are free, and adapted to engage antifriction rollers 8 mounted on a plate 7 connected with the part to be driven or with the driving part. (*Sealed.*)